IN THIS ISSUE—M. N. Forney, Wm. Forsyth, E. M. Herr, W. H. Marshall, G. R. Henderson, F. R. F. Brown, Dr. C. B. Dudley, F. N. Pease, R. A. Smart, F. J. Cole and "Motive Power."

No. 6.
Vol. LXXII.

AMERICAN ENGINEER
CAR BUILDER AND RAILROAD JOURNAL.

Sixty-Seventh Year
Established 1832.

NEW YORK:
Morse Building, 140 Nassau Street.

JUNE, 1898.

$2.00 PER ANNUM.
SINGLE NUMBERS, TWENTY CENTS.

ENTERED AT THE POST OFFICE AT NEW YORK, N. Y., AS MAIL MATTER OF THE SECOND CLASS.

"Competitive Tests of Locomotives,"

PAGE 198, THIS ISSUE,

BY M. N. FORNEY.

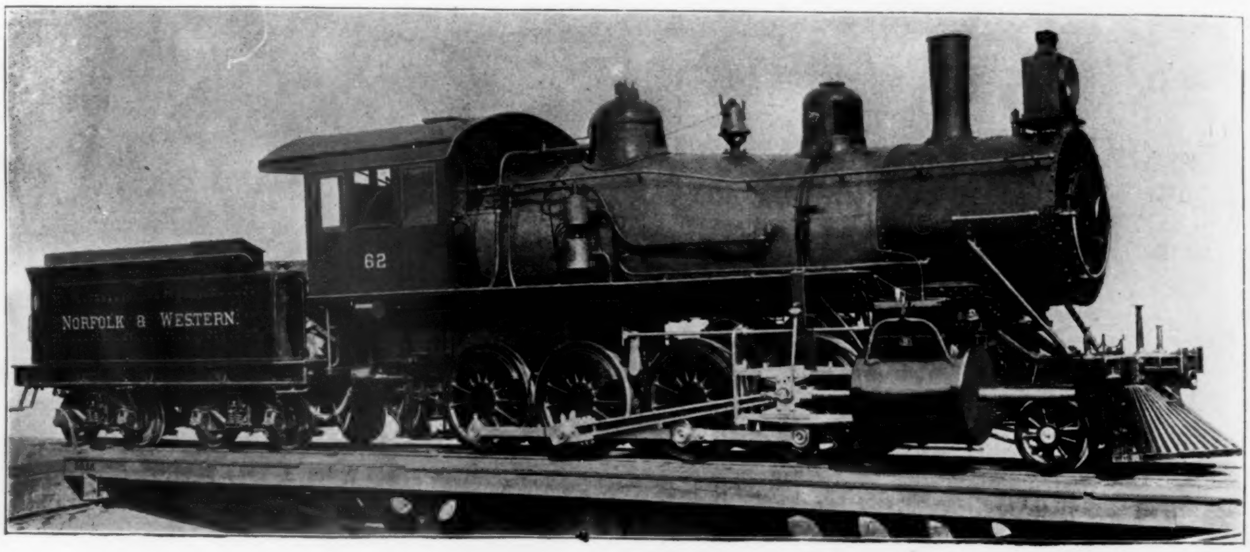


Fig. 1. From a Photograph.

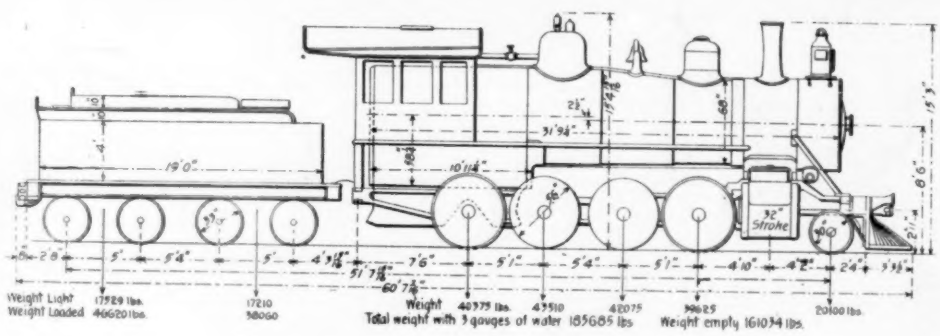
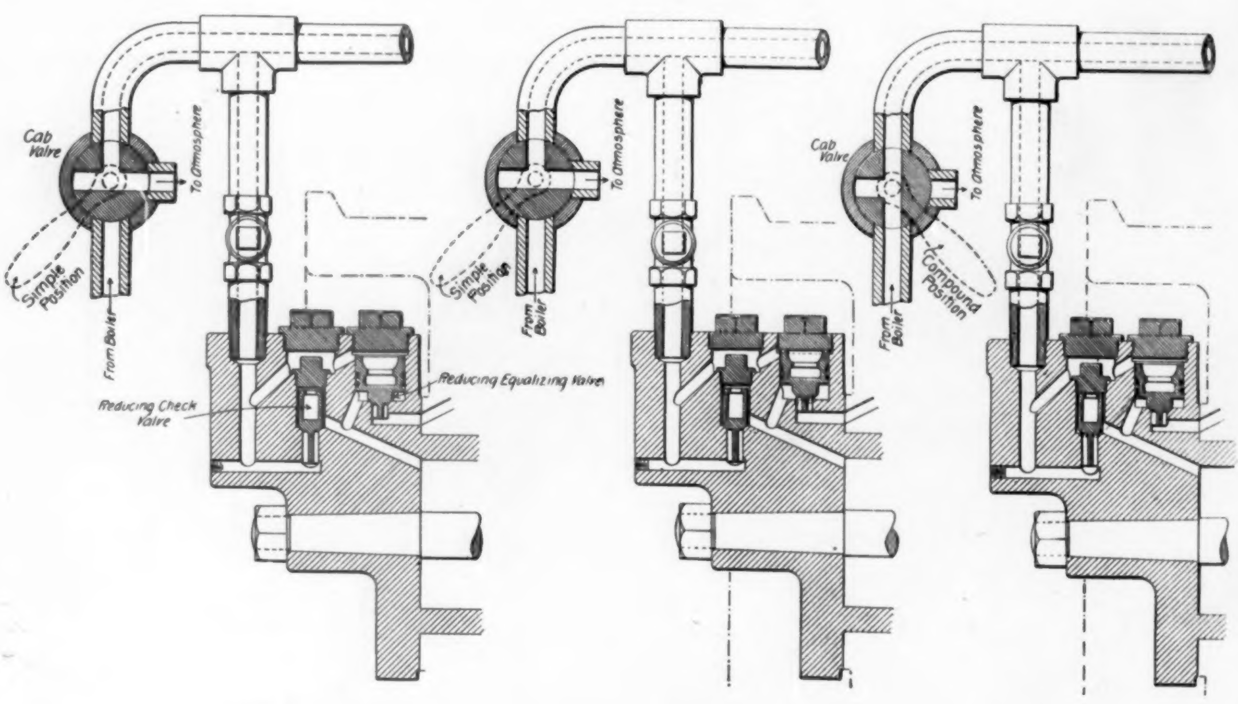


Fig. 2. Diagram of Dimensions and Weights.



With Throttle Closed. **Simple Position.** **Compound Position.**

Showing Positions of Auxiliary Valves.

BALDWIN TWO-CYLINDER COMPOUND LOCOM

W. H. LEWIS, *Superintendent of Motive Power.*

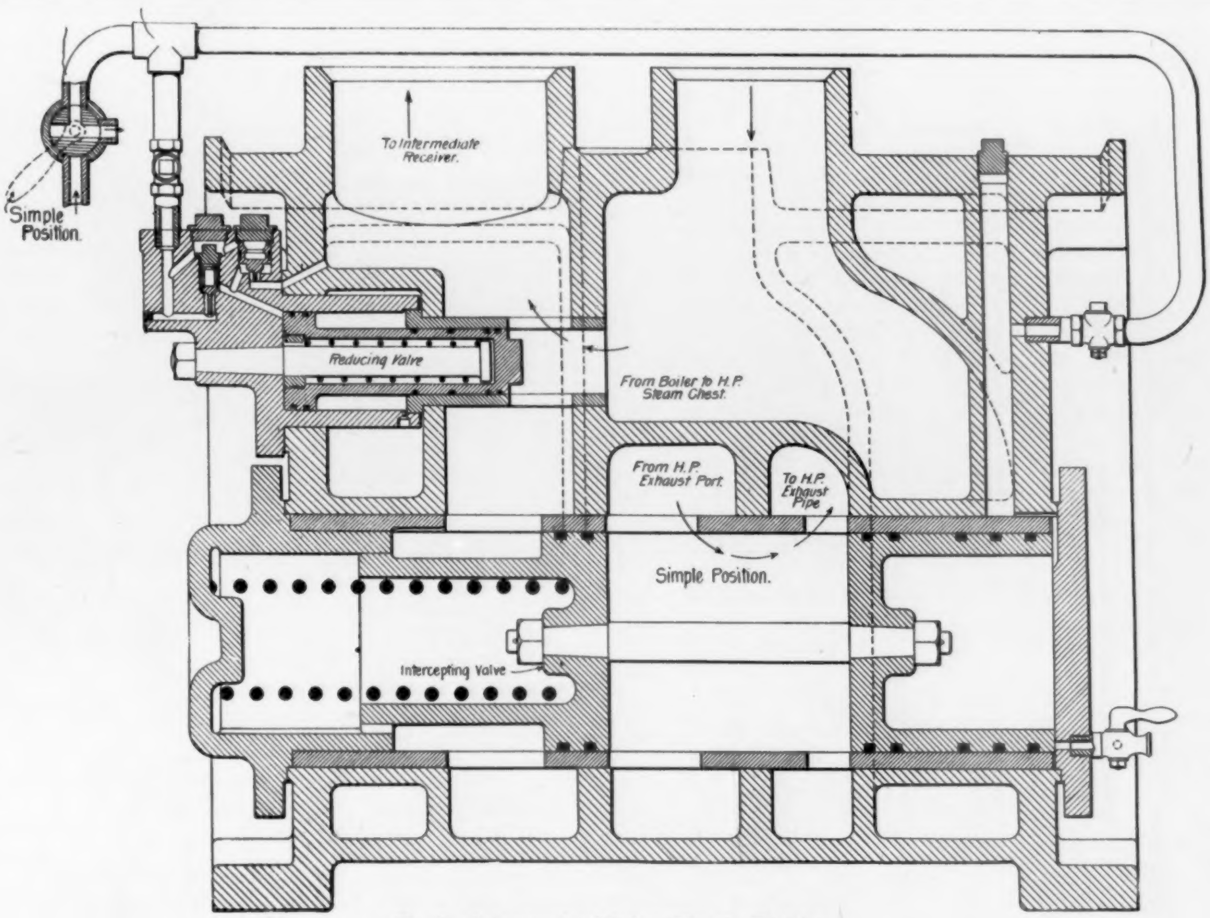


Fig. 3. Intercepting Valve—Simple Position.

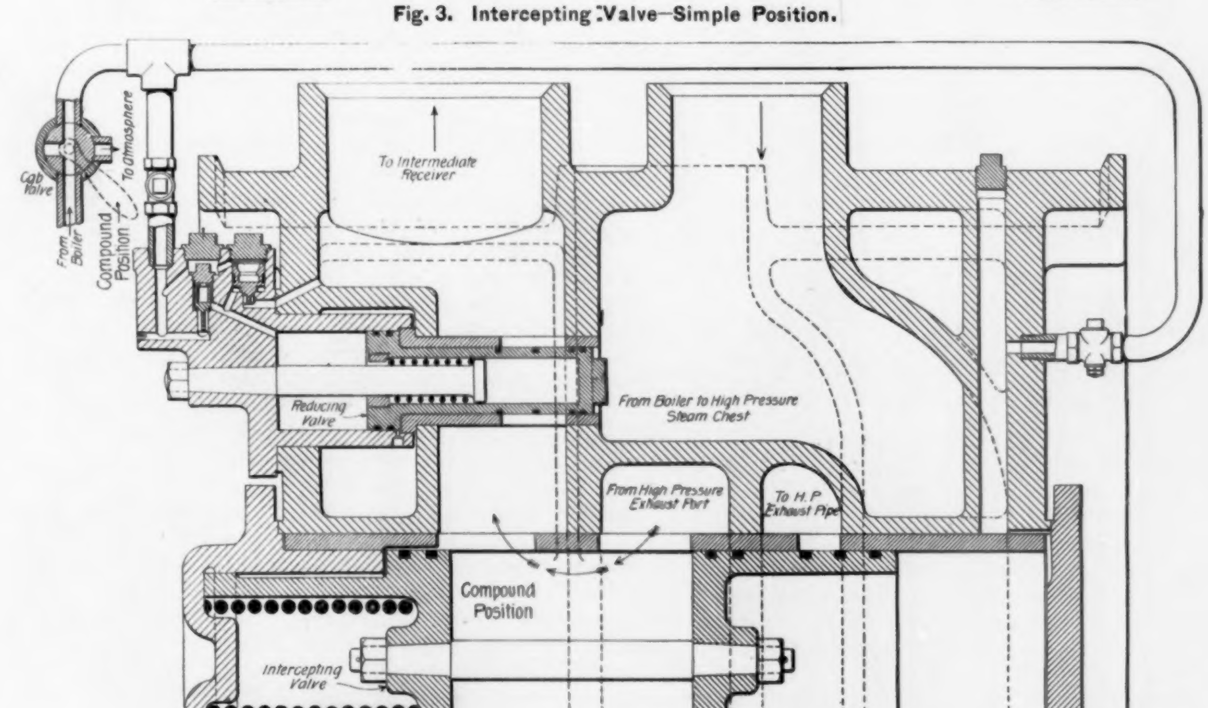


Fig. 4. Intercepting Valve—Compound Position.

D LOCOMOTIVES—NORFOLK & WESTERN RAILWAY.

G. R. HENDERSON, *Mechanical Engineer.*

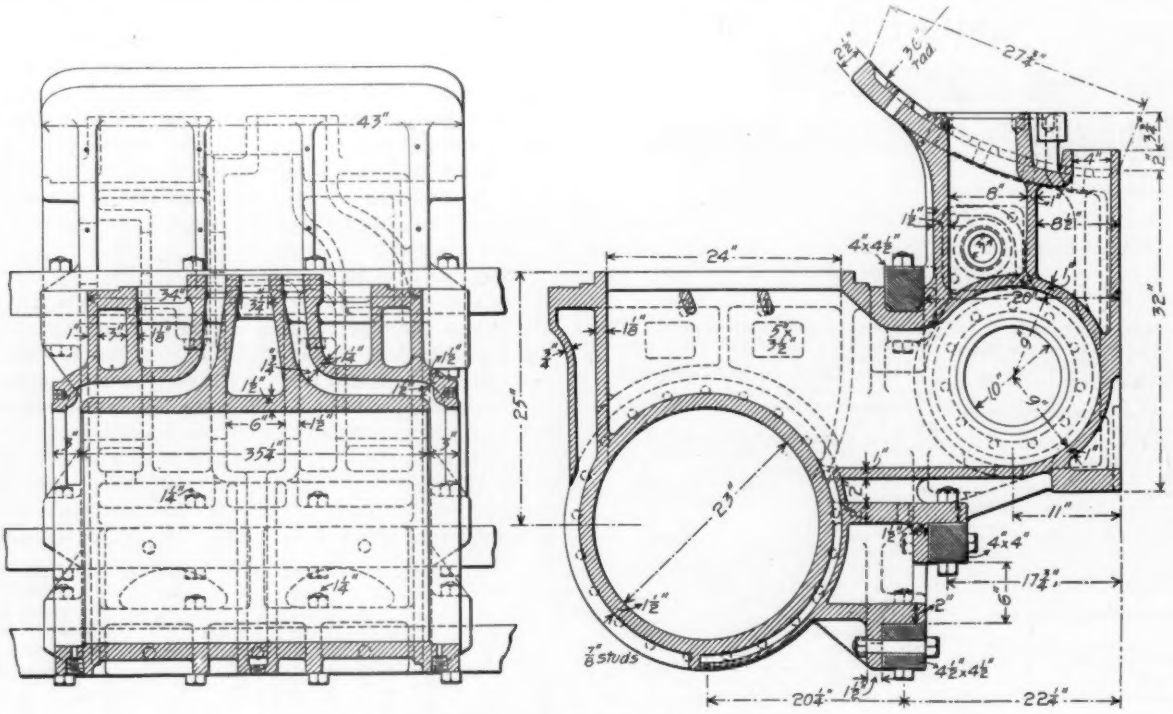


Fig. 5.—Sections of High Pressure Cylinder.

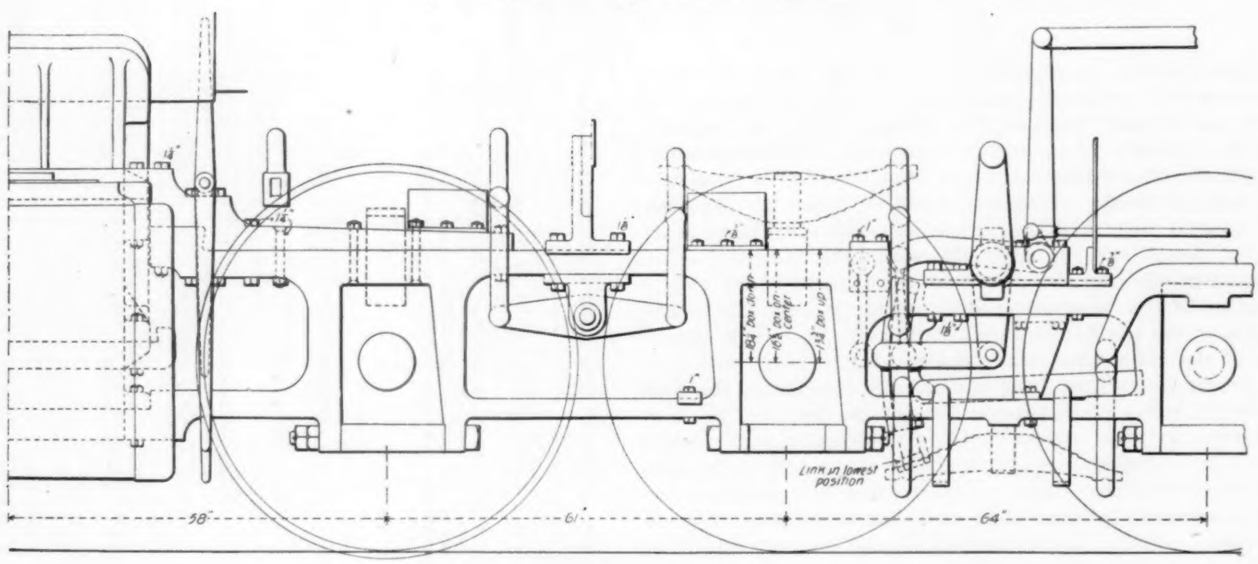


Fig. 7.—Frames and Valve Motion.

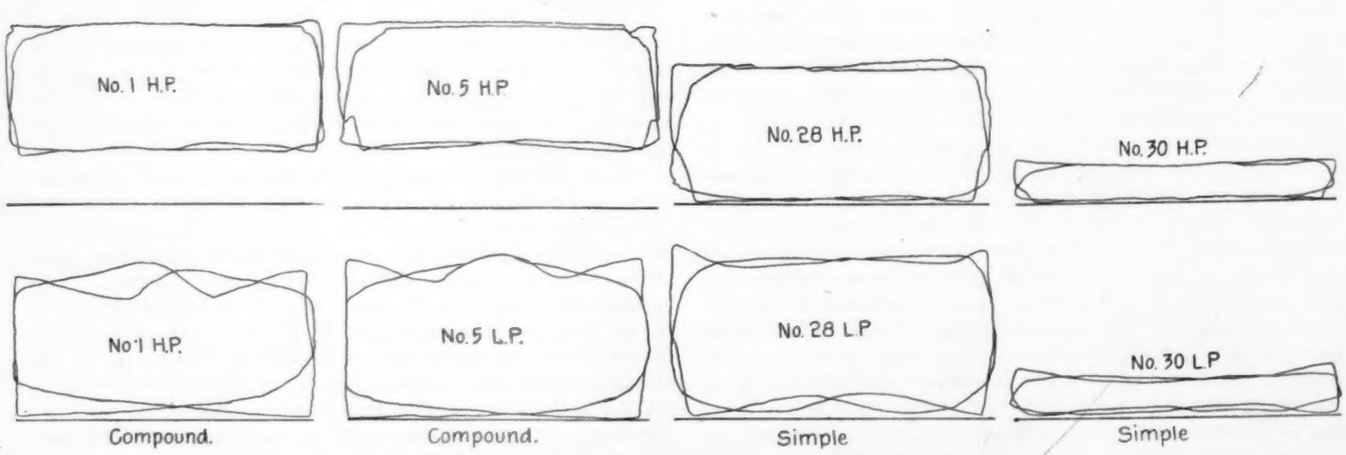


Fig. 8.—Selections from Indicator Cards—Half Size.

BALDWIN TWO CYLINDER COMPOUND LOCOMOTIVES—NORFOLK & WESTERN RAILWAY.

W. H. LEWIS, *Superintendent Motive Power.* G. R. HENDERSON, *Mechanical Engineer.*

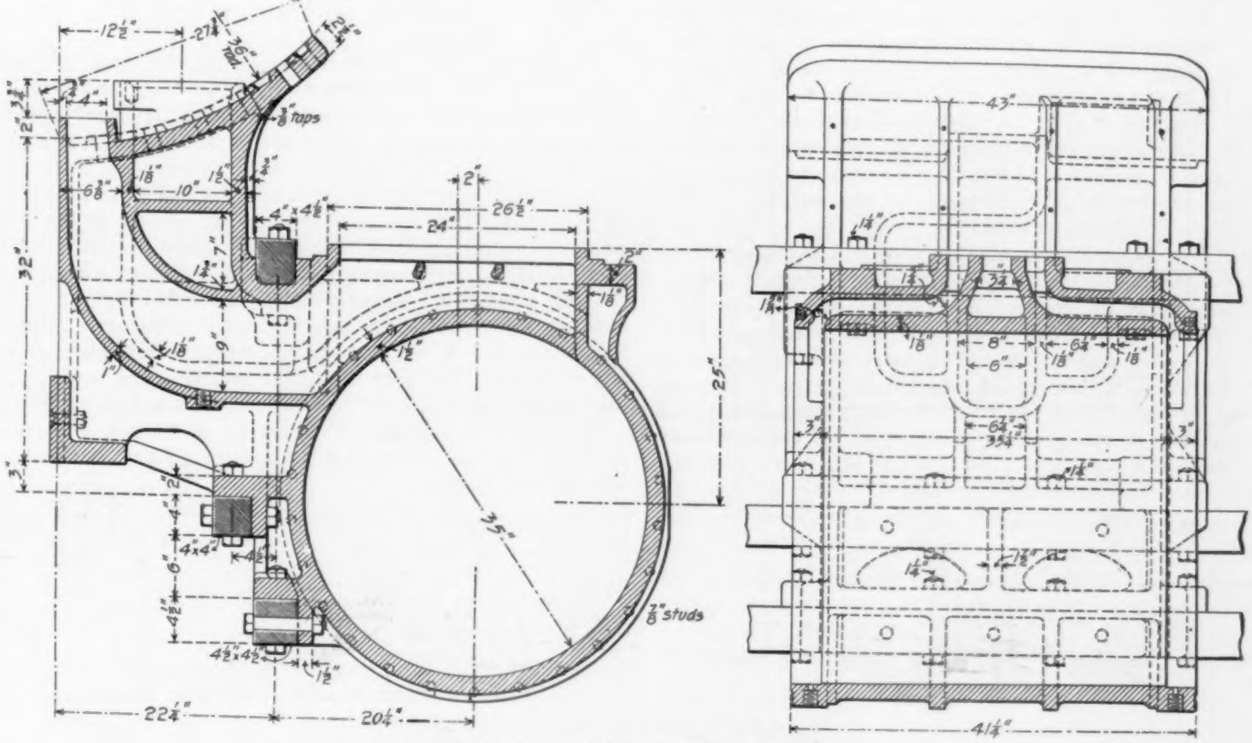


Fig. 6.—Sections of Low Pressure Cylinder.

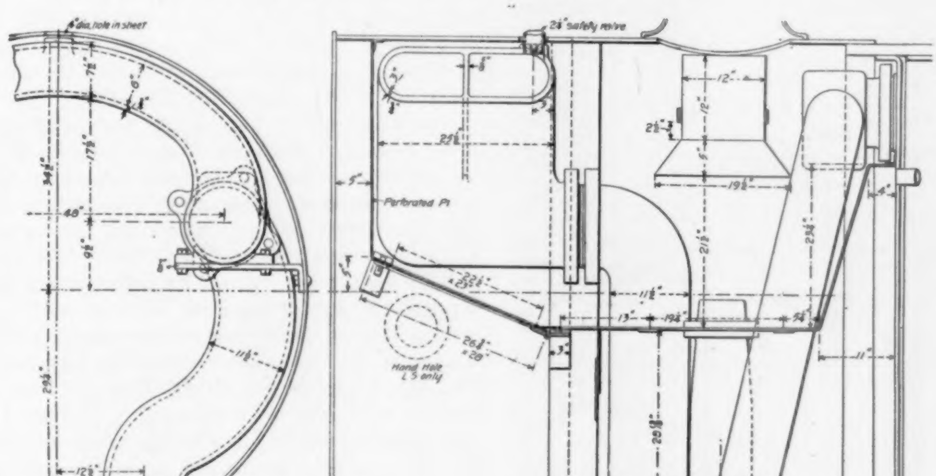


Fig. 9.—Receiver and Front End.

working, the steam from the cab valve is exhausted, whereupon the excess pressure on the underside of the reducing equalizing valve immediately lifts it so that live steam can again pass to the receiver, the intercepting valve having in the meantime gone to its original position, by the assistance of the spring in the front head, and also by the receiver pressure acting against the front end of the valve. The practical results of this arrangement can be seen by inspecting the indicator diagrams, which were taken from one of the engines while in its regular work on the mountain divisions of the Norfolk and Western Railway, and the tabulated data given shows the relative amount of work done by the two cylinders from which it will be seen that quite a close equalization has been obtained, and it will also be noticed that the indicated tractive power is very high.

In connection with the cylinders, the arrangement of frames is original. The upper bar of the main frame butts against, and stops at the back face of the cylinder, while the lower bar of this frame extends as far as the front end of the cylinder, having a lug forged on the end in order to wedge the cylinder tight. The top front end frame is spliced to the main frame with a long extension, and passes over the top of the cylinder, extending to the bumper. The bottom front end frame has no connection with the main frame, but is secured independently to the cylinders, extending from the bumper to the back cylinder face, to which it is wedged. This results in making the lower front end frame practically a straight bar from the cylinder to the bumper, and avoiding the curve or goose neck, which is often necessary in order to clear the truck. This arrangement necessitates more novelties in the detail design of the cylinder and the arrangement of ribs or arches connecting the lugs to which the frames are bolted, evidently giving great resistance to the casting at this point.

The arrangement of the receiver in the smoke box is new, and deserves particular mention, as by this means any part of the receiver can be taken down without disturbing the other connections, and it also leaves plenty of room for the inspection of the smoke box and netting. The link motion

has been so arranged that the use of hooked or bent eccentric hods has been avoided and a link of comparatively long radius introduced. The link die pin passes through a bar, which is supported at one end by the lower end of the rocker arm, and at the other end by a link having the same length as the lower rocker arm. In this arrangement the motion of the block is exactly the same as if it were secured directly to the rocker, and as it is attached between the supports of the carry bar instead of overhanging at one end, the rigidity of the parts will be much improved.

The cab is made of sheet steel, lined with wood, and is very roomy and comfortable. The crank pins and main driving axles were made of 3½ per cent. nickel steel, and the main wheel centers were of cast steel; the others being cast iron. The first, second and fourth driving axles were of hammered iron; the object of this special arrangement being to give the greatest strength where needed at the main axle, and not to increase the cost unnecessarily of the other axles that seldom give trouble by breaking. The engines are fitted with the Westinghouse and American equalized driver brake, with the double Leach sanding apparatus and magnesia sectional lagging.

It should be added that the various features relating to the compound device are covered by existing patents, or by others which have been applied for and not yet granted. The following table is given for the purpose of comparison with other designs:

Gauge	4 ft. 9 in.
Diam. driving wheels	56 in.
Wheel centers, main	cast steel
" " 1st, 2d and 4th	cast iron
Tires	Latrobe steel
Total wheel base	24 ft. 6 in.
Rigid wheel base	15 ft. 6 in.
Diam. driving axle bearing	8½ in.
Length " " "	10½ in.
Main driving axle	nickel steel
Other " "	hammered iron
Diam. main crank pin bearing	6½ in.
Length " " " "	7 in.
Diam. main side rod bearing	7 in.
Length " " " "	5 in.
Diam. intermediate " "	6 in.
Length " " "	5 in.
Diam. 1st, 2d and 4th side rod bearing	5 in.
Length " " " " " " "	3½ in.
Crank pins	nickel steel
Diam. truck wheels	30 in.
Truck wheels	cast iron, steel tired
Diam. truck axle bearing	6 in.
Length " " "	10 in.
Truck axle	hammered iron
Diam. high pressure cylinder	23 in.
" low " "	35 in.
Length of stroke	32 in.
Spread of cylinders	85 in.
Type of valve gear	shifting link
Travel of valve	5⅞ in.
Lap of valve	1 in.
Lead " "	1-16 in.
Length of steam ports	24 in.
Width " " "	2⅛ in.
" " exhaust "	3 in.
Center to center of frames	44½ in.
Minimum external diam. of boiler	68 in.
Maximum " " " "	77¼ in.
Type of boiler	extended wagon top
Top of rail to center boiler	8 ft. 6 in.
Number of tubes	306
Outside diam. of tubes	2¼ in.
Length between tube sheets	14 ft. 5 in.
Heating surface of tubes	2,598.5 sq. ft.
" " " fire box	197.5 sq. ft.
" " total	2.796 sq. ft.
Length of fire box	10 ft. 1 in.
Width " " "	3 ft. 5½ in.
Height " " " (front)	6 ft. 2 in.
Grate area	35 sq. ft.
Minimum diam. of taper smoke stack	15 in.
Top of stack from top of rail	15 ft. 3 in.
Width of cab	12 ft. 4 in.
Exhaust nozzle, single	5¼ in.
Boiler pressure	200 lbs.
Weight of engine, empty	161,000 lbs.
" " " working order	185,700 lbs.
" on drivers " "	165,600 lbs.
" " truck, " "	20,100 lbs.
Brakes	Westinghouse and American
Leach sanding apparatus, double.	
Magnesia sectional lagging.	
Capacity of tank	4,000 gals.
Capacity for coal	17,000 lbs.
Diam. tender wheels	33 in.
Material " "	cast iron
Diam. tender truck journals	4¼ in.
Length " " "	8 in.
Weight of tender, empty	34,700 lbs.
" " " full	84,700 lbs.

NEW 60,000-POUND COAL CARS—LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

This design is for special service in the coal and ore trade from Lake Erie ports and for use with the McMyler unloading machine. In this machine the car is tipped endwise at an angle of about 45 degrees and a lifting end gate allows the coal to slide through the open end, over an apron and directly into the hold of the vessel. This admits of no projections that would interfere with the easy sliding of the coal, either to crush it or form pockets that would hold it. In this service the cars are loaded to their full capacity and often to the full amount of excess weight allowed. Although of a marked capacity of 60,000 lbs., the box is sufficiently large to hold 66,000 lbs. of coal, and the construction throughout is designed to carry this load in regular service. The body of the car is known as Class F-6 and the truck Class L-6.

The general dimensions of the car are as follows. Five hundred of these cars have just been built by the Buffalo Car Manufacturing Co.:

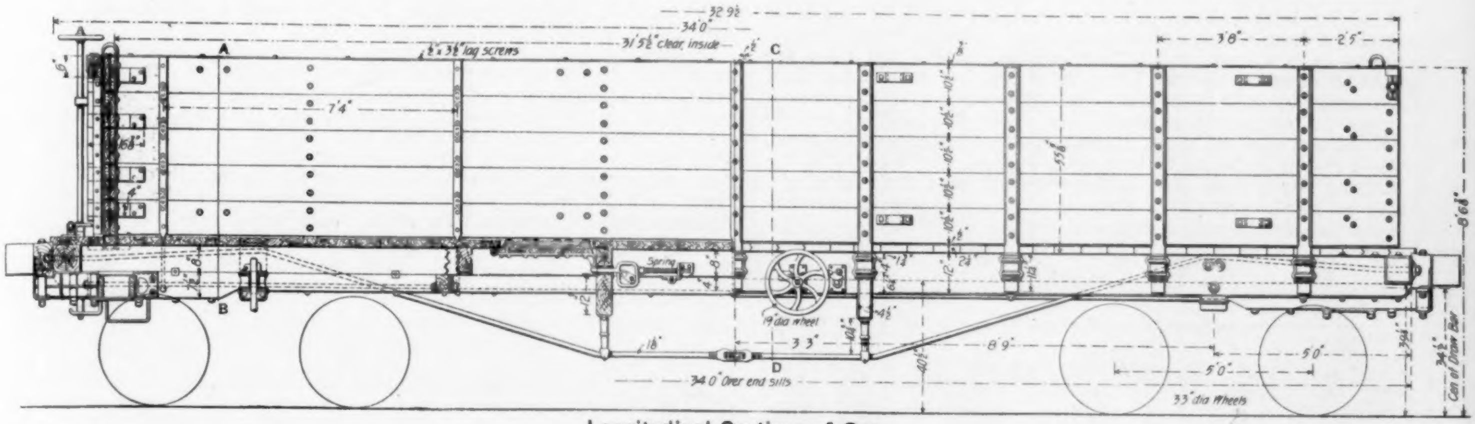
	Ft.	In.
Length over end sills	34	..
Length inside box	31	5½
Width over side sills	8	9
Width inside box	8	3
Height to top of box	8	6⅞
Height over brake shaft	9	6¼
Height of box inside	4	5⅝
Length of drop opening	2	4
Width " " "	1	10

There are eight longitudinal sills of long leaf yellow pine. The side sills are 4½x12 in., with 4-in. lips under the end sills. The center and intermediates are 4½x8 in., spaced 8 in. apart, the outside intermediates being spaced 10¾ in. from the side sills. The end sills are of 8x8 in. white oak, extending 3 in. beyond the faces of the side sills. The drop door sills are of 4½x8 in. white oak, framed between the center and outside intermediates. The cross tie timbers are of 4½x 12 in. white oak, spaced 6 ft. 6 in. apart.

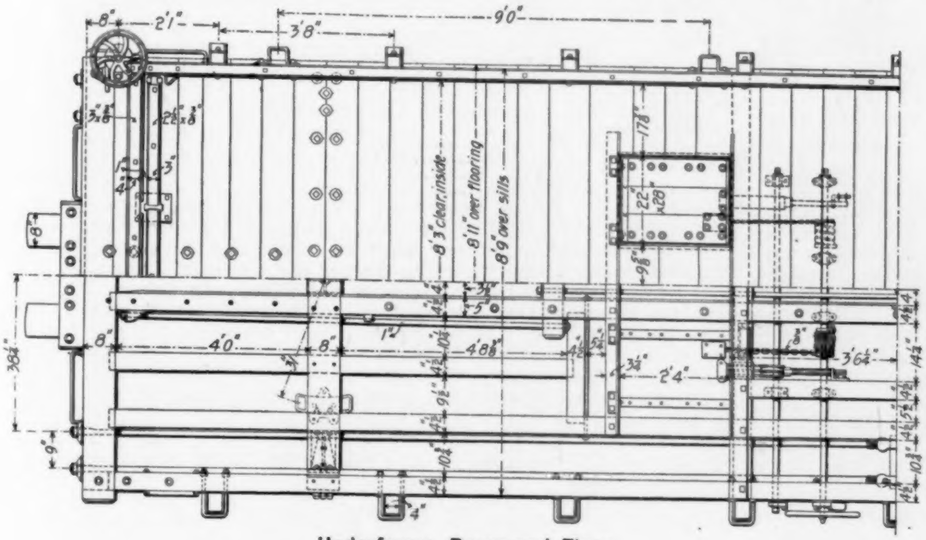
The body bolsters, located 5 ft. from each end, are formed of three members, the upper one, ¾x8 in., in sections, being on top of the floor timbers and lipping under tne side sills. The ends of the bottom member, which is ⅞x8 in., in section, are turned up and butt against the top member, while a malleable casting secured with bolts firmly unites the ends and forms a truss rod saddle. The center member forms a support for part of the floor timbers, and combined with the central part of the bottom member forms a separate truss. A malleable distance piece secures the members at the center. The side bearings are of cast iron and the center plates of pressed steel. There are four 1⅛ in. body truss rods with cast iron bearings 10¾ in. deep bolted to the cross-tie timbers. The sub floor timbers are of 5x5 in. yellow pine, extending from the draft rod cross timbers to the centers of the body bolsters. Similar pieces are fitted between the cross-tie timbers and from the cross-tie timbers to the draft rod cross timbers.

In the floor near the center of the car are four drop doors for unloading through the floor when desired. The surface of these doors is flush with the top of the floor so that no pocket is formed to catch coal when in the unloading machine. The locking mechanism for these doors follows the principle of an ordinary doorlatch, except that the spring latch is on the sills instead of the door. The doors are closed by a chain winding on a drum. When closed the latch automatically locks the door, and the arrangement is such that the door cannot be left nearly closed supported by the chain. The sides of the box are formed of 3 in. plank supported by 9 strong stakes in malleable iron stake pockets. Two stakes on each side are longer and lip over the ends of the cross-tie timbers. At the ends the sides are held in position at the top by an oak strut and a tie rod. Several years' experience, with this form of construction and size of material, shows that the sides are sufficiently strong to withstand the load without spreading.

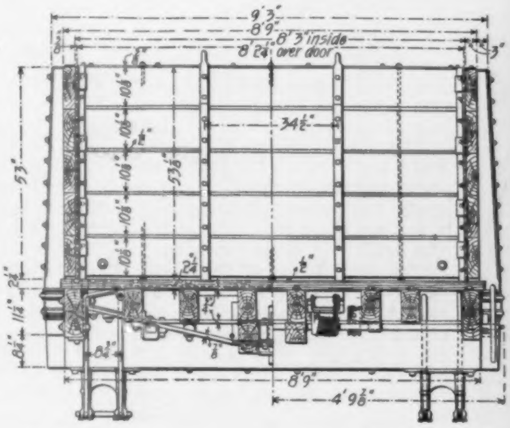
The end doors lift to permit the load to dump, as already mentioned. The brake shafts are put at the corners to be out of the way. The end doors are of 5 planks 3x10⅛ in., stif-



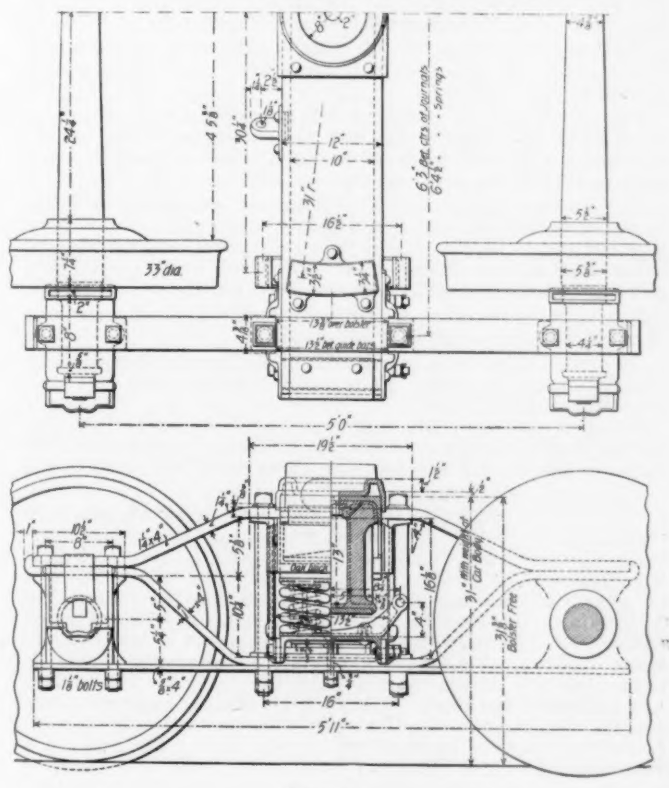
Longitudinal Sections of Car.



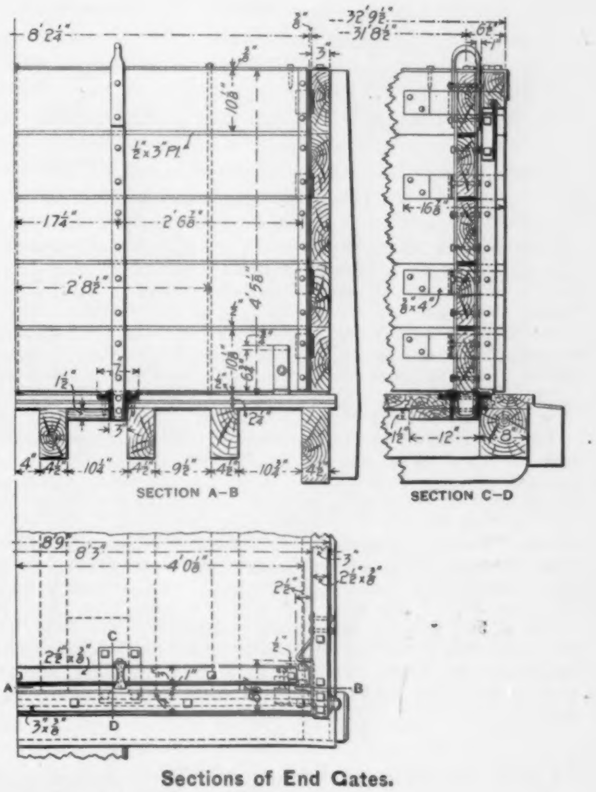
Underframe, Doors and Floor.



Section A–B. Section C–D.



Trucks.

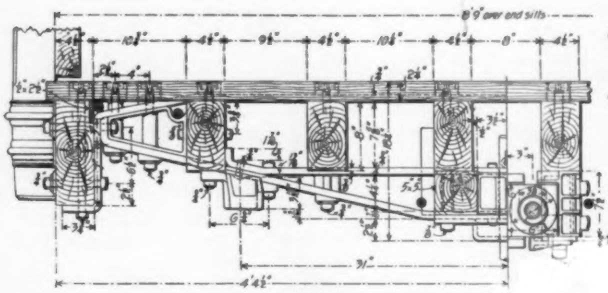


Sections of End Gates.

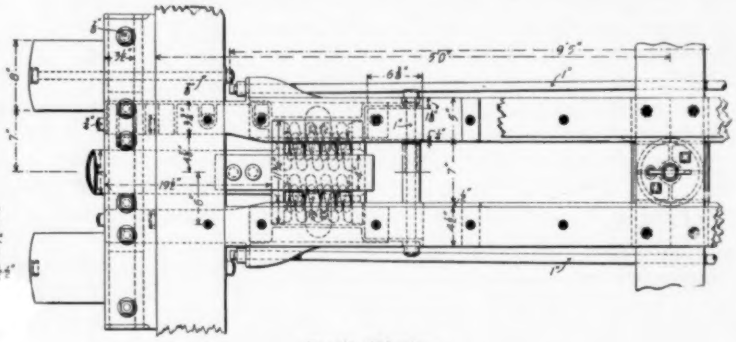
60,000-LB. COAL CARS–LAKE SHORE AND MICHIGAN SOUTHERN RY.

For Use with McMyler Car Dumping Machine.

fened by 4 wrought iron straps, and protected by bands of wrought iron. The doors carry lugs, which enter socket plates in the floor, and lifting stirrups at the top edge are used to raise the doors. The guides for the ends of the door are made by a 3x3 in. angle on the outside and a series of stops of ⅝x4 in. iron on the inside of the door. The doors do not lift out entirely when raised. Eight auxiliary stake pockets of 2½x½ in. wrought iron are provised. The flooring is 2¼ in. long leaf yellow pine laid crosswise. The drop openings, four in number, are 2 ft. 4 in. by 22 in., and are located between the intermediate and center floor timbers.



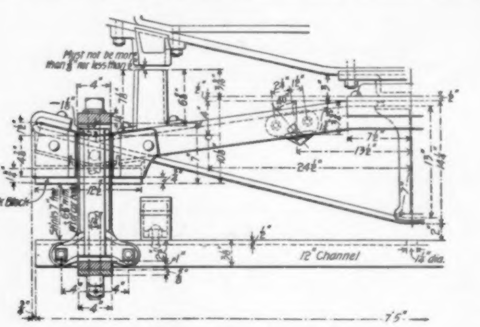
Section Showing Body Bolster.



Draft Rigging.

The draft timbers are white oak, 5x7½ in., extending to the body bolsters. The draft springs are double, with two coils each. Gould draft arms are used, each being connected to the draft rod cross timbers by a one-inch rod passing through a lug on the outer side of the arm. Two ⅞ in. rods connect the draft rod cross timbers.

The trucks are of the rigid, diamond frame type, with two types of bolsters, American steel and the Simplex. The drawing shows the latter. The spring plank is a 12-in. 30-lb. steel channel. At the bearing between the bolster spring plates and the truck bolster a pocket is formed in the end of the bolster,



One Half of Truck Bolster.

which takes a block of oak about 12 in. square and of a varying thickness. By changing the thickness of this block the height of the coupler above the rail is readily controlled. Malleable iron journal boxes, having round bottoms, are used. Steel axles, 600-lb. wheels, graduated bolster springs and steel center plates are parts of this class of trucks. Attention is called to the large radii of the bends in the arch bars, made to insure against fracture in what are ordinarily sharp corners The journals are the M. C. B. standard for 60,000-lb. cars.

The following special equipment was furnished: Brakes by the Westinghouse Air Brake Co.; National Hollow Brakebeams, "Peerless" air brake hose; Gould couplers; Cleveland Forge & Iron Co.'s turn-buckles, Lappin brake shoes, one-half the springs by the A. French Spring Co., and the other half by the Chas. Scott Spring Co., McCord journal boxes and Soule dust guards. The malleable castings were made by the National Malleable Castings Company. Gould spring buffers were used on 200 of the cars, 100 had the American steel bolster. A lot of 500 similar cars were ordered for the P. & L. E. R. R., from the Michigan Peninsular Car Co. We are indebted to Mr. A. M. Waitt, General Master Car Builder of the Lake Shore, for the drawings and information concerning these cars.

PROFESSOR GOSS ON THE AIR RESISTANCE OF TRAINS.

An elaborate series of tests on the air resistance of trains made by Professor Goss of Purdue University, and described in a paper before the Western Railway Club in April, throws a great deal of light upon the hitherto obscure question of how trains are affected by the atmosphere.

The experiments were made upon small models, constructed to a scale of 1-32 of the size of the ordinary box car, the assumption being that relative resistances will be directly proportional to the surfaces of the cars, and that conclusions drawn from the small models will apply to the full size trains. Professor Goss presents the matter for practical use in the form of equations, in which the factors of the length of the train and the area of cross sections are considered, the head resistance and the resistance of the cars being provided for independently. Tables worked out from these formulae give the horse power and tractive power required for speeds of from 10 to 100 miles per hour, with the locomotive and tender running alone and with a train. Tables are also given, showing the resistance of trains both with and without the locomotive, the length of trains being from 100 to 2,000 feet. These three tables sum up his results in a very convenient form, which, if the assumption referred to is correct, will be exceedingly valuable.

The apparatus consisted of a wooden conduit, 20 by 20 inches in section, by 60 feet long, the sides of glass and air tight. The air current was furnished by a blower, giving a maximum velocity of 100 miles an hour, the velocity being measured by Pitot's tubes. The model cars were placed near the center of the conduit, each being provided with a dynamometer for measuring the resistance, without attempting to obtain any data on side resistance. The limits of the velocities were 25 and 105 miles per hour, and the number of models used was from 1 up to 25. The conclusions drawn are quoted as follows:

The force with which the air current acts upon each element of the train, or upon the train as a whole, increases as the square of the velocity.

The effect upon a single model, standing alone, measured in terms of the pressure per unit area of cross-section, is approximately 0.5, the pressure per unit area as shown by the gage recording the pressure of the air current.

The effect upon the different models composing a train varies with different positions in the train; it is most pronounced upon the first model, the last model coming next in order, then all the intermediate models excepting the second, and least of all is the effect of the air upon the second model.

The relative effect upon different portions of the train is approximately the same for all velocities.

The ratio of the effect upon each of the several models composing a train, measured in pressure per unit area of cross-section, compared with the pressure per unit area of the air current, as shown by the gage is approximately: for the first model 0.4; for the last model 0.1; for any intermediate model between the second and last 0.04; and for the second model 0.032.

The chaotic condition of the experimental work on train resistance, involving, as it does, wheel, axle and flange friction; the resistance of grades, curves, and atmosphere is most unsatisfactory, and it is apparent that tests which attempt to take all of these into account simultaneously will furnish but little information, and this unique and admirable investigation seems to be a forward step in clearing up a part of this troublesome problem, the tendency of this investigation being to show that the results figured from the formulae hitherto in use are much too high. It is to be hoped that supplemental reports will be made by the same experimenter upon the internal resistance of locomotives. It will probably be too much to expect that the effects of side winds will be accurately known, but if the other factors can be isolated from each other the number of unknown quantities will be minimized. It is to be hoped that the exact relation between the resistance of the small model, and the full size car will be shown to supplement and corroborate these results.

THE CONSTRUCTION OF A MODERN LOCOMOTIVE.*

IV.

By Motive Power.

Blacksmith Shop.

Probably in no other branch of the work required in the construction of a locomotive has there been less improvement over hand methods or in introduction of machinery to take the place of hand work than in blacksmith work. While there is good reason for much of this there remains a great deal of work now done by hand or with indifferent facilities, which, with the application of a little thought and the adoption of improved methods, can be vastly improved, not only in quality but in quantity. The blacksmith shop may be very advantageously divided into two special departments, one in which the smaller class of work is done, and which should include bolt work and all of the machinery used in connection with that and other small forgings, and the other a department in which all of the heavy forging is done, and which can properly be known as the hammer shop. By reason of the difference in the requirements it will probably be found cheaper to have the installation pertaining to the hammer shop located in a separate building, specially constructed for the purpose of getting ample ventilation, and reducing fire risks. Both of these departments should be located conveniently near to the machine shop, requiring the least amount of handling of the finished product to that point. The general arrangement of the facilities in either one of these departments should be such that the work done in them will progress in regular stages toward completion, and when completed have its location the shortest possible distance from the point at which it is to be used. All of the scrapping or making of iron, as well as the heavier forgings, is carried on in the hammer shop, at one end of which should be located, in close proximity to convenient tracks, the storage for scrap. The character, sorting, piling and other detail connected with handling of the scrap should receive the closest attention, care being used to avoid the introduction of pieces that are too small or pieces that are too large, the general character of the scrap when piled should be such that it will heat uniformly with a minimum amount of waste, which would not be the case where a wide discrepancy in the size and proportion of the pieces which make up the pile exists. With the increased use of mild steel in standard shapes, and furnished in competition with iron, there is great danger that this character of material will become mixed with the scrap, all of which is supposed to be iron. We know of no more simple and satisfactory method of sorting this out than that relying upon the man at the shear, who with proper experience can usually tell by the nature of the cut or fracture whether the piece is steel or iron. All of the scrap used should be thoroughly "rattled," and in quantities each day about equal to the consumption, for the reason that the scale or rest on the average scrap if not removed in this way becomes loosened in the heating of the pile in the furnace, and in the average process of working this pile into a bloom there is no way for this scale to work out, and it will frequently show itself in the form of dirt in seams in the finished forgings. To avoid recorrosion this scrap should only be rattled in quantities equal to consumption. The facilities for rattling this scrap should preferably consist of two tumbling barrels, located in close proximity to the scrap stored, and provided with facilities for filling and emptying large enough to handle the material in large amounts. An installation of this kind in connection with the hammer shop will more than repay its original cost in the satisfactory forgings which will result from scrap prepared in this way.

For the purpose of keeping track of the exact cost of bloom iron made directly from the scrap, it has been found satisfactory to issue an annual work order covering its manufacture. A record of the car loads of scrap received during the current month, with a record of scrap on hand at the beginning of the month, should be kept, together with a supervision which shall provide that on or about a certain date at the end of the month there shall not be more than the correct amount of scrap on hand, generally speaking not exceeding one-half car load. This will be found an easy and simple way of keeping track of scrap consumed during that current month. Each day or night product of bloom iron should be carefully weighed, and at some convenient portion of the bloom a small portion chipped off with an ordinary cutter, and the weight and date made stamped on with steel letters; the object in cutting off this small fraction is that this surface will quickly rust and make that portion of the bloom on which the date and weight is marked more prominent when these blooms are piled in the yard. All of the forgings made in the hammer shop, and made from this bloom iron, are charged with this iron, which is carried in stock in similar manner to other material, and the forgings paid for as forgings at so much a piece, which price has been determined on a tonnage basis. Unless arrangements are provided whereby the limit weight is set, we question the economy of the tonnage system in working up forgings, and believe for the reason that it is possible to determine a limit weight, that it is more satisfactory to arrange the price on a basis of so much per forging. Owing to the isolation of the making of bloom iron from the other kinds of forgings, every facility exists for determining not only the average waste of the scrap which is used, but the cost going into the manufacture of this bloom iron in all its details. There is danger in setting too low a price on the actual work required in working up the piles into blooms, and this price per ton should be such as to discourage scant working of the iron at this stage of its manufacture, as it has been found that a low price encourages scant working, and that the extra work required to make good the defects developing in forgings later on more than offsets the difference between too low price and one which would produce better blooms in the earlier stage of the operation. It will be obvious that some of the forgings required in the locomotive will require larger blooms than others, and to avoid unnecessary handling of heavy blooms for light forgings, a schedule of sizes or weights of blooms is prepared and used for determining the stock sizes of blooms which shall be made; the price and kind of blooms are governed by the type or class of engine under construction, and for which the forgings are required. The amount of bloom iron on hand is reported at the end of each month, and comes under the supervision of the foreman of the blacksmith shop, who has charge of both the blacksmith shop proper and the hammer shop.

Frames.—Too much care cannot be used in the forging of frames, and when finished they should have as few welds as possible. The backbone and one-half of each pedestal leg on all frames should be of one piece. Frames 28 feet long have been worked up in this way with quite ordinary facilities, with no difficulty, and when finished make a very satisfactory job. A forging of this character is made by continuous piling and working out of blooms taken from stock, each bloom being of such a size and shape that one can be made to lap on the other, and when well worked, form practically a continuous forging. For a frame whose cross-section would be about 4 by 5 inches, the blooms used for piling on should have a cross-section equal to at least 6 by 8 inches. This will insure a thorough working down of the bloom into a smaller size, and complete homogenuity in the finished forging. As stated, the pedestal legs form a part of this forging for one-half of their length down from the back bone, and the intermediate braces have solid with them the other half of the leg, from the bottom up, so that the only welds in a frame of this type will be in each one of the pedestal legs at the center of their

*For previous article see page 147.

length. This not only locates the welds where the least strain will come, but at a point where they can most easily be made, consistent with the keeping of the frames straight in piecing up, and allowance for expansion and contraction is more easily taken care of here than would be the case in back bone welds, or other old methods. Care should be taken in the making of the back bone in this way not to use too large a bloom for piling on, as the reduction to forging size at the juncture of the bloom and the finished forging is very apt to give a small section, which in the heated condition of the iron would break away. The working down of the bloom to a finished forging should be done gradually, leaving a fillet of long radius; in other words, the difference in size should not be too abrupt. The use of shaped dies in working out intermediate braces, with their portions of pedestal legs, will be found very satisfactory and will reduce the time required and also make the forgings more uniform. The welds on pedestal legs above referred to should be of the double "V" type, one side of each "V" being made at a time, and the filling piece used in this form of weld heated in a separate heat. This will practically prevent an accumulation of dirt in the weld, and also enable the forgeman to observe the condition of the weld.

Forging Presses.—Hydraulic forging presses of not less than 1,200 tons capacity, and capable of making at least 50 strokes per minute at a maximum, will be found of great value in the hammer shop in getting out the smaller forgings, which are usually worked out entirely under the hammer. One of the advantages of this class of machinery lies in the fact that it practically completes the operation on the piece in one stroke, and, the wear on the dies being very much less than in the ordinary process of hammer work, more expensive dies can be used and their life is very much greater. With a machine of this kind forgings may be worked out with not exceeding 1-16 inch to 1-8 inch finish, and in a large amount of the link and valve motion work the forgings made sufficiently close to size to only require a process of grinding for their completion.

Fires and Oil Furnaces.—In connection with a press of this type an annealing furnace should be used, especially in connection with steel forgings. The action of forming forgings of intricate shape in one heat has a tendency to change the granular structure and reduce tensile strenth; this may be overcome by proper annealing and should by all means be resorted to where the forging is done in this way. In contradistinction to the hammer shop, the blacksmith shop should be equipped for all of the smaller grades of forgings, including bolts, etc., and it will be found with the introduction of machinery of comparatively simple kinds that the number of fires required in the ordinary blacksmith shop, where this machinery is located, may be very materially reduced. In this shop, and possibly some would prefer it in the hammer shop, all of the heating should be done by fuel oil supplied by means of a properly installed system and burners, which will give the maximum amount of efficiency with a minimum amount of oil. In this connection we would like to state that we do not consider any of the low pressure systems operating the ordinary forms of burners for burning this oil economical. While some of them are capable of operation without excessive smoke, it will be found in almost all cases that the oil consumption per pound or hundred pounds of product is greater than with a satisfactory type of burner using high pressure air or steam for its operation. The only proper and satisfactory way to burn fuel oil is in the form of gas, and to do this it requires a high pressure for vaporization of the oil, and a proper generating chamber for the formation of the gas. The gas formed will be found to more conveniently heat and permeate every part in the furnace in which it is burned than any flame of burning oil directly from a burner can ever do.

Bolts and Bolt Machines.—As the result of a large number of experiments it has been found that the ordinary run of bolts can be satisfactorily headed at one operation; in other words, without the use of top, bottom and side hammers on the average bolt machine, and bolts when made of iron, headed in this way, give a better distribution of the grain of the iron in the head than where they are repeatedly hammered into shape in the average bolt making machine. It will, however, be found for some sizes that even where the average bolt machine is left to do the work in this way that the ram moves entirely too fast for the work. It requires a certain amount of time for iron properly heated to flow, and the ram in the machine must be timed accordingly to give satisfactory results. Dies for doing this work may consist of the ordinary gripping dies, which when together form practically one solid die, and the ram of the machine forming the other portion of the die practically making a closed die. The accuracy of alignment which it is necessary to maintain in the machine, will be more than compensated for in cheapness and large amount of the output. A very satisfactory form of machine for this purpose and in successful operation consists of two hydraulic cylinders, one of which operates the gripping dies and the other the heading dies. The cylinders are so arranged in connection with the operating valve that the gripping die will act first and the heading die second in the beginning of the operation and the reverse of this at the finish. A machine of this kind, capable of exerting not less than five tons pressure for every square inch of forging contact, or a total pressure of 35 tons, will be found exceedingly useful not only for bolt work but for other classes of forgings used on a locomotive, and in fact a great variety of small forging work where a large pressure is required and slowly applied. Experiment has demonstrated that the speed of this machine should be variable at will, and according to the character of the work which it is required to do. Five of these machines, varying in capacity from 35 to 60 tons, would be found equivalent to about twelve ordinary blacksmith fires. All of the iron required for bolt work should be cut to length, and can advantageously in some cases be cut sufficiently long so that two bolts can be made from one piece; in other words, a head made on each end and the bar afterwards cut in two in the center. We do not consider it good practice to make bolts of any kind where a thread is required on the end, from a bar heated for a large amount of its length. The scale which ordinarily exists on the bar is bad enough without making it worse by the additional scale, and frequently of a very much harder kind, which will form when the bolts are made in this way. Experience has demonstrated that the life of the dies used in cutting the threads on bolts which are made from iron cut to length is fully one-third more than when they are used for cutting bolts made from the bar heated for sufficient of its length to make several bolts from the one heat, and these bolts cut off in the machine. With a proper oil burner and properly constructed furnace with perforated fronts, perforations matching very nearly the size of the iron, heats can be secured on the iron in length just sufficient to make the required head, and we have seen any number of cases where the bolt iron cut to length, the heat was not sufficient in that portion of the iron outside of the furnace to discolor the threaded end. It is also true that with this kind of heating there will be very much less oil consumed than in the case where from three to four feet of the bar is heated at one time and bolts cut off in the machine. The absence of large furnaces and that class of machinery which usually is arranged in the hammer shop, which should be a separate building, will do away to a very large extent with the excessive heat and dirt in the blacksmith shop such as we have described. The introduction of oil as fuel in furnaces which do not require any stack and which would properly burn the oil together with machinery for quickly forming, in carefully made dies, the smaller forgings required on the locomotive will so materially reduce the number of ordinary forge fires required that this shop should be comparatively clean and cool. Such forge fires as are required should be equipped with oil,

thus doing away with the dust and dirt from ashes attendant on the use of coal. For the purpose of avoiding unnecessary rehandling of that class of material, the machinery for machining and cutting bolts can be arranged in the blacksmith shop in comparatively close proximity to the point where the bolts are made, and the finished product delivered directly to the erecting shop where it is used. The accumulation of short ends of bar iron, unless carefully watched, becomes a very expensive kind of scrap, for the reason that the general tendency is to cut off lengths required from a full length bar, and it frequently happens that ends left from bars of quite a respectable length will find their way into the scrap pile, and which would answer for the regular run of bolt work. At some convenient point in the shop a series of bins sufficient in number to cover the average range of sizes, should be arranged to contain these short ends, and they should be regularly collected from the smith fires or points where they are likely to accumulate and put in these bins. The lengths which will average about the same should be selected from time to time and used up on running orders of bolt work. This will not only prevent pieces of excessive length accumulating in the scrap, but will use up the material more closely and economically. At the end of each month these bins should be carefully gone over and the shortest pieces which would answer for scrap taken out, their weight kept, and thrown in the regular scrap stock, which stock should receive credit for that amount of material and that credit reported in the regular way to the keeper of stores. It also happens that from time to time there is an accumulation of scrap of sufficient size for working over in the various other departments, and this scrap should be regularly sent to the regular scrap pile, the weight being carefully taken, and the scrap stock given credit in similar manner to the case above referred to.

Finishing Forgings.—Located in the hammer shop, there should be several cold saws of sufficient capacity for the heaviest forgings which will require trimming. These forgings can go direct to the saws from the hammers, and in many cases the trimming which these saws will do will be all the machine work which will be required on that surface. An installation of from three to four machines provided with an automatic saw sharpener and proper lifting appliances can be readily handled by one man; as the forgings leave these saws they will be ready for delivery to the machine shop. The location of these saws in the hammer shop will save the handling of what otherwise would be much heavier forgings, as well as the transfer back of the scrap stock of material removed by the saws in case they were located in the machine shop.

Tools and Tool Making.—In the blacksmith shop should be located a separate department in which all of the forgings required for tools and all of the hardening and tempering, annealing, etc., is done, and in charge of an experienced man. Outside of the tools required at the hammers, all of the tools used by the blacksmiths should be made in this department and taken charge of by this department. It is not considered good practice to allow the indiscriminate manufacture of tools by the blacksmiths throughout the shop, as they can be made very much more quickly and cheaply in a department provided with the proper facilities for that purpose. These facilities may consist in addition to forge fires principally of either hammer or hydraulic presses, provided with dies of the proper shape to form in one or not exceeding two operations the complete tool required. All of the tool steel required throughout the works may be carried in this department, and each lot of tool steel received should be subject to a careful test by the man in charge, who must thoroughly understand the manipulation of this material. We have known cases where several hundred dollars' worth of steel has been made into tools and proved utterly worthless, owing to change in the mixture by the manufacturers of which the consumer was not aware of at the time of its receipt. The test applied need not be elaborate and may consist of the usual drawing out, annealing, hardening and bending under various conditions, and also the hammer refining test. A record of these tests either by retaining the original pieces, or careful description with the maker's name, of the steel will serve as an indication of how uniform the steel furnished may be running, and it is preferable that the man in charge of this department should work in close harmony with the man who has charge of the small tool department, and who manufactures the steel into the finished shape.

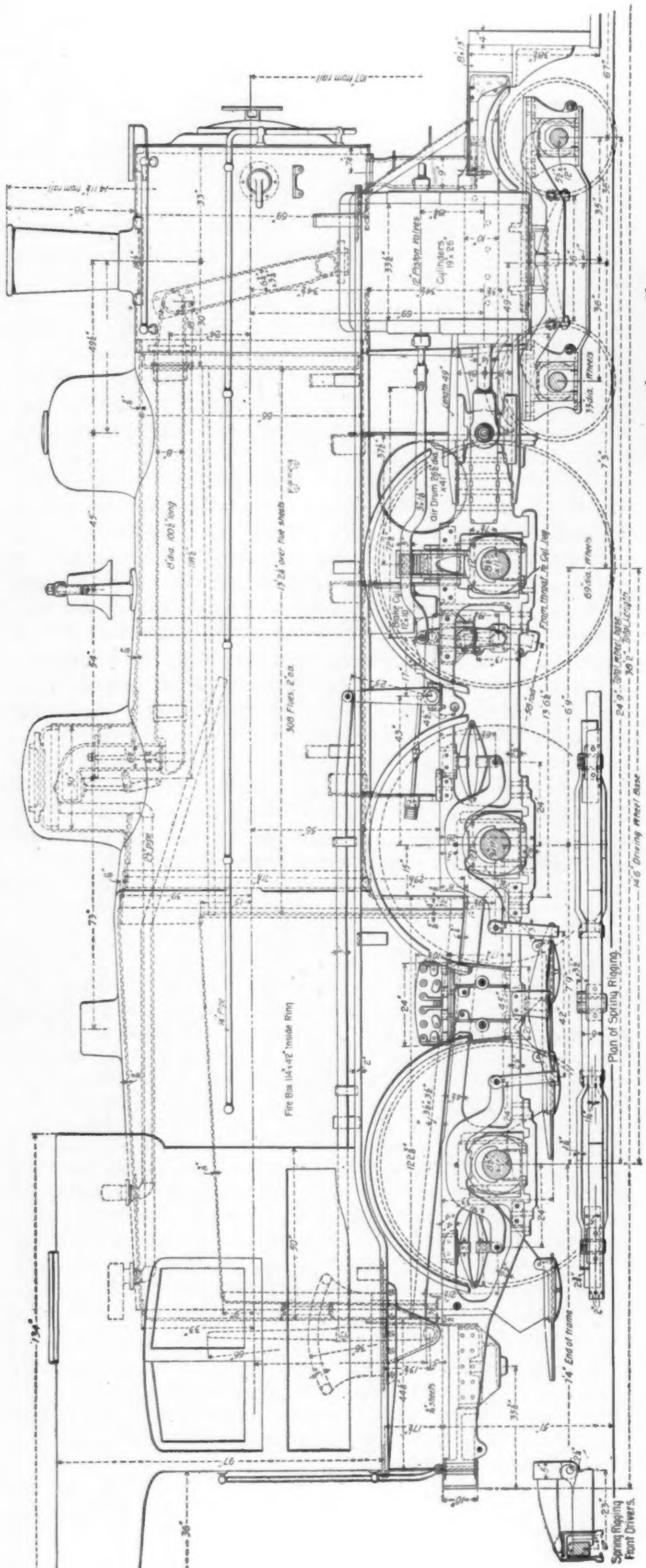
Order of Doing Work.—Both the hammer shop and blacksmith shop having been supplied with a schedule for the getting out of the parts referred to in previous article, the order in which the forgings and material from both departments will be furnished will be in accordance with the requirements of the erecting shop, making proper allowance for the time required for machine or finishing in the machine shop. Generally speaking the heavier classes of forgings, such as frames, guide yokes and other forgings which pertain to frame work direct, as well as the forgings which are provided for the boiler, are required first. Whether the practice may be that of cutting off the stay bolts to length and screwing them in with a special nut for the purpose, or providing a square on the ends for the purpose of screwing them in, in all cases the bar should be marked or stamped on the square indicating the make of the stay bolt iron, for the purpose of designating this iron until it is used up and in order to keep careful record of the kind of stay bolt iron used in any one particular class of boilers. It has been found convenient where squares are provided on the end of the bolt to stamp the letter in the heading die so that with each operation of forming the square the letter is stamped on the end of the rod. It is of course understood that in all of the larger forgings such as frames, guide yokes, rods, etc., that these forgings leave the hammer shop ready for machining in the machine shop, and that the welding up or piecing up of frames is done in the hammer shop, the blacksmith shop proper being reserved entirely for the smallest grade of forgings required in the construction of the locomotive.

COLLEGES.

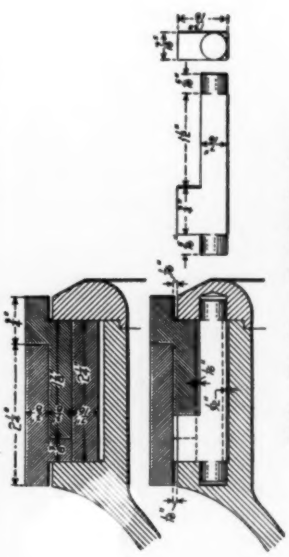
Cornell University, Summer School, Announcement of Courses of Instruction.—The summer school of Cornell University, for teachers and advanced students, will be open this year from July 5 to August 13, and those interested may obtain copies of the announcement on application. A number of courses have been arranged for those who desire to advance themselves as draftsmen, engineers and electricians, open to any one without entrance examinations. Among these are: Dynamo laboratory practice and lectures, mechanical drawing and designing and laboratory work. The last mentioned course includes the testing of materials and lubricants, determination of quality of steam; analysis of coals and flue gas; calibration of dynamometers, weirs, steamgauges, steam-engine indicators, and other engineering apparatus; efficiency tests of the hydraulic ram, water motor, injector, boilers, pumps, air compressors; steam, gas, oil, and hot air engines. For further particulars the circular should be consulted.

"West Virginia University. Announcement for the Summer Quarter 1898." This circular contains a statement of the work of the university for the advantage of students who do not wish to lose the time during the summer vacation. The drawing room, field practice, shops and laboratories will be open during the summer. Information may be had from Wm. S. Aldrich of the Department of Mechanical Engineering, Morgantown, W. Va.

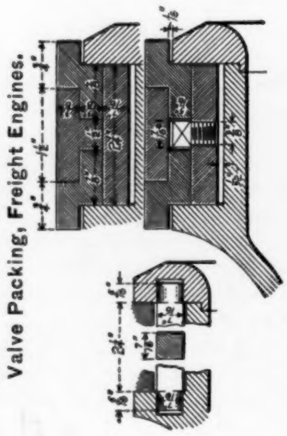
Massachusetts Institute of Technology, Entrance Examinations.—The usual plan of holding entrance examinations for this school in twenty-one different cities of the United States on June 30 and July 1 will be carried out this year, particulars of which may be obtained from Dr. Harry W. Tyler, Secretary, Boston, Mass.



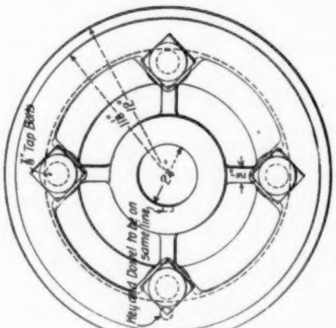
General Elevation.

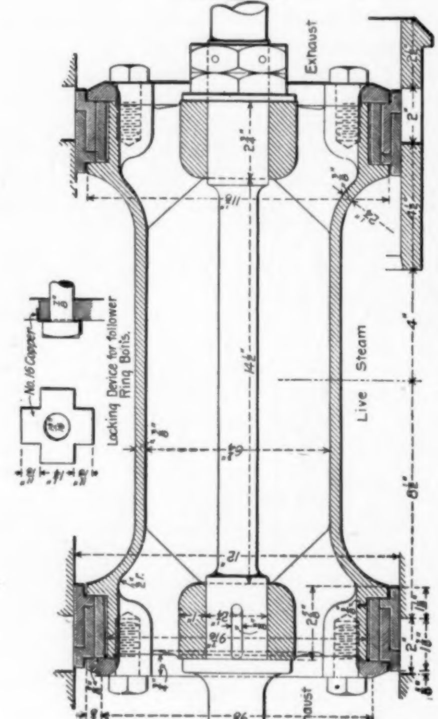


Valve Packing, Freight Engines.



Valve Packing, Passenger Engines.

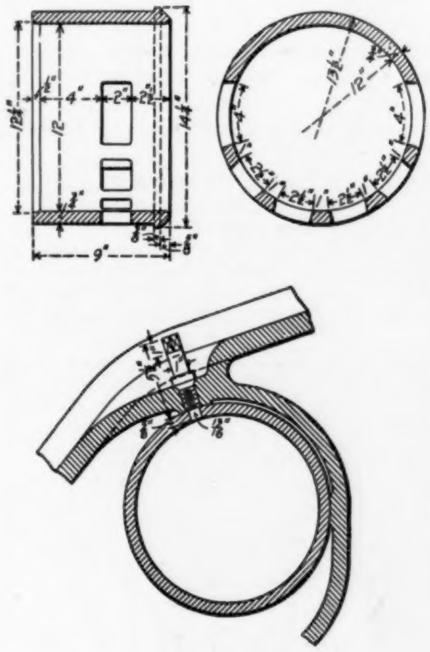




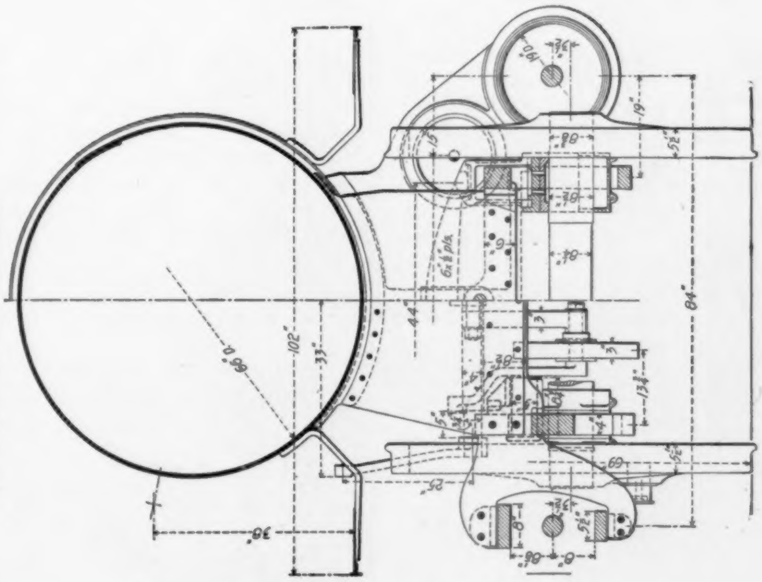
Section Through Piston Valve.

TEN-WHEEL PASSENGER AND FREIGHT LOCOMOTIVES, WITH PISTON VALVES—WISCONSIN CENTRAL LINES.

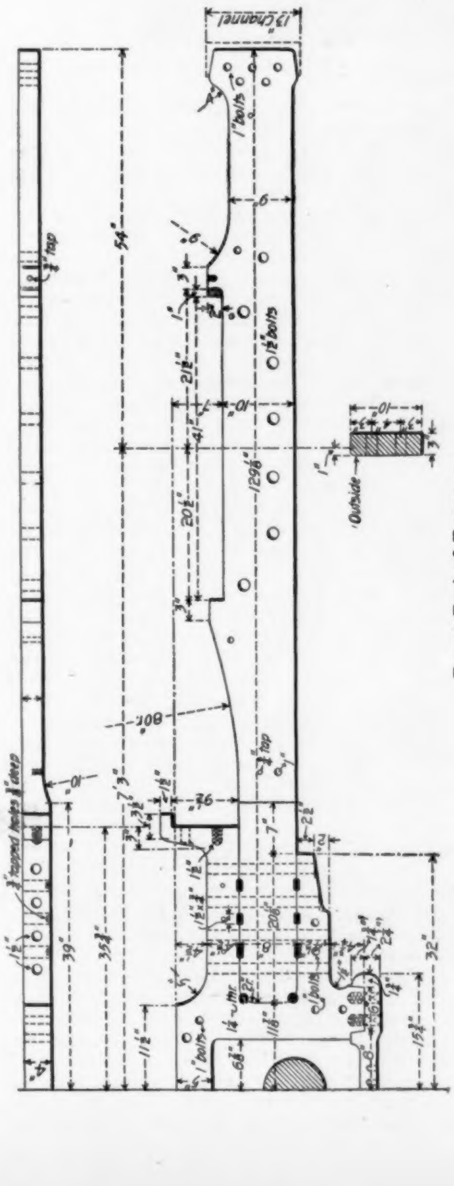
JAMES MCNAUGHTON, *Superintendent of Motive Power.* BROOKS LOCOMOTIVE WORKS, *Builders.*



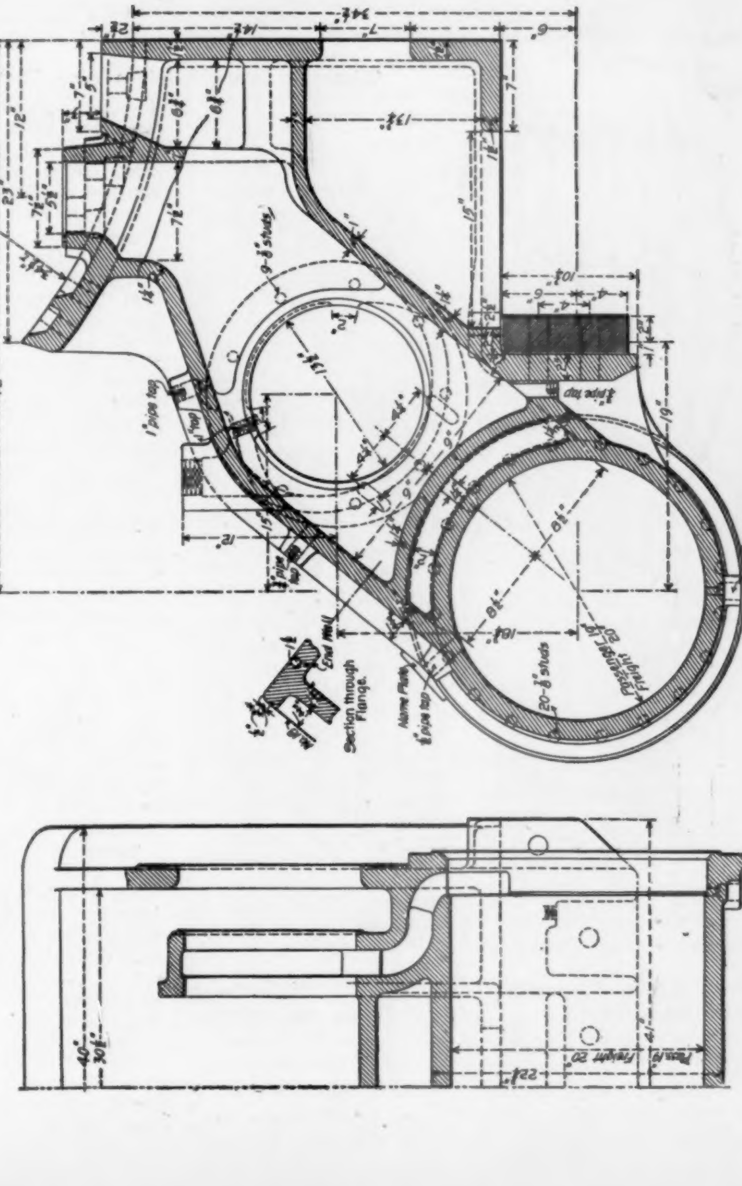
Valve Bushing and Fastening.



Sections Through Guide Yoke and Driving Box.



Front End of Frames.



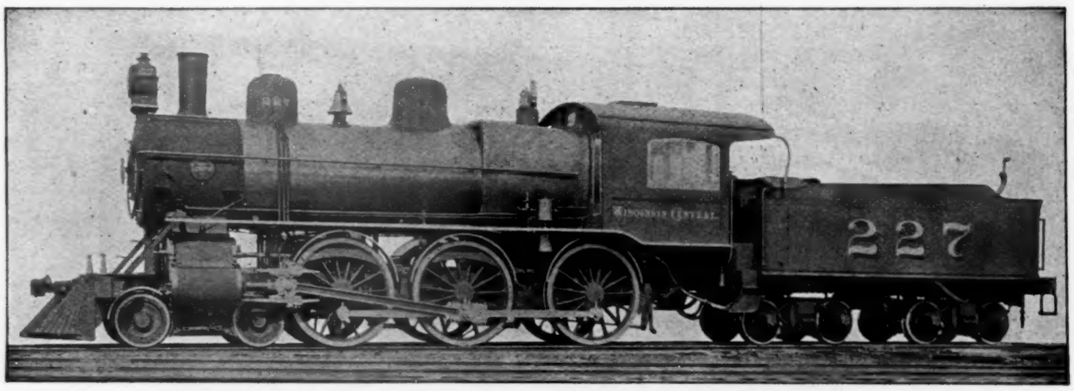
Sections of Cylinder and Valve Chamber.

TEN-WHEEL PASSENGER AND FREIGHT LOCOMOTIVES, WITH PISTON VALVES—WISCONSIN CENTRAL LINES.

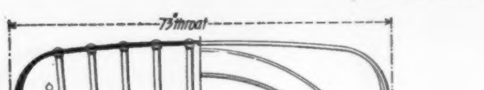
JAMES MCNAUGHTON, *Superintendent of Motive Power.* BROOKS LOCOMOTIVE WORKS, *Builders.*

SIMPLE TEN-WHEEL LOCOMOTIVES WITH PISTON VALVES—WISCONSIN CENTRAL LINES.

Four ten-wheel passenger and six freight locomotives of the same type have just been delivered to the Wisconsin Central Lines by the Brooks Locomotive Works. The drawings are specially interesting because of the application of piston valves. The passenger engines have 69-inch and the freight 63-inch driving wheels, while the cylinders of the passenger are 19 by 26 and of the freight 20 by 26 inches. The weight of both engines in working order is about 150,000 lbs. The heating surface is 2,300 square feet and the grate area 32.4 square feet. The piston rods are 4 inches in diameter. The steam ports have an area of 36 square inches and the exhaust ports an area



Wisconsin Central Engines—From Photograph.



Section Through Firebox and Main Driving Box.

of 65.5 square inches. The boiler is the Player patent, Belpaire type with a sloping firebox over the frames. The passenger engines have truck brakes and all of the engines have the arrangement of spring hanging shown in one of the engravings, in which a 42-inch spring is employed as an equalizer while the other driving springs are elliptic with curved levers resting on the tops of the driving boxes for the main and rear drivers, the forward drivers being connected across the engine to an equalizer in the form of a 46-inch spring, which rests on saddles over the driving boxes. The heavy springs have 6 by ½-inch leaves. We are informed that the engines ride remarkably well. The springs have long hangers which will tend to reduce the amount of wear on the ends of the springs to a minimum. This is important and is not always well provided for.

The front and rear end of the frames are unusually deep, and at the cylinders they are 3 inches wide and 10 inches deep, the tongues are 8 inches deep at the frame splices and 9 inches deep in front of the cylinders. The pistons are of the bull ring type, hollow with three packing rings. The front cylinder heads are cast iron and the rear ones cast steel and very thin and light. The steam chest covers are circular and the forward ones have stuffing boxes to receive the extended valve rods, and with this plan the valves should be perfectly balanced. It is open to question, however, whether the pressure of the steam under these rings will not cause considerable friction against the bushings.

On page 3 of our January issue and again on page 85 of our March issue, of this volume, we illustrated the piston valves made by these builders for the Great Northern engines, and a comparison will be interesting. The valves of the Wisconsin Central engines have internal admission, and the inside clearance of ⅛-inch is at the outside edge of the valves, while the steam lap is on the inside. This arrangement brings the live steam to the center of the valve through a passage that is surrounded by exhaust steam, and in this respect is similar to the design of piston valves by Mr. G. R. Henderson, shown on page 39 of our February issue. The form of the valve and the bushings and packing are shown in the engraving. The packing for the freight engines is like that of the Great Northern design and is shown in place in the sectional drawing of the valve.

In the arrangement for the passenger engines the Z shaped rings are cut at an angle of 45 degrees, the lower ring is cut square across to fit the dowel pin that is held in place by the follower plate and the upper ring is prevented from turning by cutting the rib out to admit the head of the dowel stud that is screwed into the lower ring. The Z shaped rings are turned ⅛-inch large, cut and sprung into the top ring. A glance at the end view of the valve will show the location of the dowel pin in the valve packing. The valve is thin, being only ⅜-inch thick in the shell, which is hollow. The valves work in cylindrical bushings, which are removable from the cylinder castings. They are ¾-inch thick and have six steam ports of which two are 4 inches long and the rest 2½ inches, all of them being 2 inches wide and having 1-inch bridges between them. The bushings are held in place by set screws, as shown.

These engines are fitted with Mr. J. Snowden Bell's patent arrangement for the front end draft appliances. The most novel features except the valves are the cylinder frame fastenings and the spring hanging. Mr. James McNaughton, Superintendent of Motive Power of the road says the spring rigging is "a decided success."

The valve gear is also novel. The rocker arms are both at the same end of the rocker shaft and both inside the frames, and there is but one tumbling shaft arm instead of two, the arrangement being shown in the section taken through the guides. The engines are doing excellent work and the use of this type of valve is another step toward what many people think will be common practice in a few years. The following table gives the chief dimensions of the engines, both freight and passenger:

Type.	10 Wheel Passenger.	10-Wheel Freight.
Gage	4 ft. 8½ in.	
Kind of fuel to be used	Bituminous coal.	
Weight on drivers	116 000 lbs.	115,000 lbs.
" " trucks	34,600 "	34,000 "
" " total	150 000 "	149,000 "
Average	75.000 lbs.	
Weight tender loaded maximum	94,000 "	
Wheel base, total, of engine	24 ft 9 in.	
" driving	14 ft. 6 in.	
" total (engine and tender)	52 ft. 2 in.	
Length over all, engine	38 ft. 2 in.	
" " " total, engine and tender	62 ft. 6 in.	
Height center of boiler above rails	8 ft. 11 in.	8 ft. 8 in.
" of stack above rails	14 ft 11½ in.	14 ft 8½in.
Heating surface firebox and arch pipes	189 sq. ft.	
" " tubes	2111 "	
" " total	2300 "	
Grate area	32.4 "	
Drivers' diameter	69 in.	63 in.
" material of centers	Cast steel	
Truck wheels, diameter	33 in.	
Journals, driving axle, main	9 in. x 11 in.	
" " " front and back	8 ½ in x 11 in.	
" truck	5½ in. x 12 in.	
Main crank pin, size	6¼ in. x 7 in.	
Cylinders	19 x 26 in.	20 x 26 in.
Piston rod, diameter	4 in.	
Main rod, length center to center	119 in.	
Steam ports, length	18 in. } area, 36 sq. in.	
" " width	2 in	
Exhaust ports, length	2½ in.	
Bridge, width	Least area, 65 5 sq. in	
Greatest travel of valves	7 in.	
Steam lap (inside)	1⅛ in.	
Exhaust lap or clearance (outside)	⅛ in. clearance	
Lead in full gear	$\frac{1}{16}$ in.	
Boiler working steam pressure	200 lbs.	
" thickness of material in barrel	⅝ in	
" " " tube sheet	¾ in.	
" diameter of barrel	66 in.	
Seams, kind of horizontal	Quintuple.	
" " " circumferential	Double.	
Dome, diameter	30 in	
Firebox, type	Sloping, over frames.	
" length	113 in	
" width	41 ⅜ in.	
" depth, front	78 in.	
" " back	60 in.	
" thickness of sheets	Side, $\frac{5}{16}$ in.; crown and back, ⅜ in.; tube, ⅝ in.	
" brick arch	On water tubes.	
" mud ring, width	Back, 3½ in.; sides, 3½ in.; front, 4 in.	
" water space at top	Back, 4½ in; sides, 5 in; front, 4 in.	
Grate, kind of	Rocking.	
Tubes, number of	308	
" outside diameter	2 in.	
" thickness	No. 12 B W. G.	
" Length over tube sheets	13 ft. 2¼ in.	
Smokebox, diameter outside	69 in.	
" length from flue sheet	63 in.	
Exhaust nozzle, diameter single	4⅞ in., 5 in., 5⅛ in.	
" distance of tip above center of boiler	1 in.	
Stack	Taper.	
" least diameter	15⅞ in.	
" greatest diameter	18 ⅞ in.	
" height above smoke box	38 in	

Tender.

Type	Eight wheel, steel frame.
Tank capacity for water	4,500 gals.
" " " coal	8 tons.
" material	Steel
Tank, thickness of sheets	$\frac{3}{16}$ x ¼ in.
Type of under frame	Steel channel.
" " springs	½ elliptical.
Diameter of wheels	33 in.
" and length of journals	4¼ in. x 8 in.
Distance between centers of journals	6 ft. 3 in.
Diameter of wheels fit on axle	5⅝ in
" " center of axle	4¾ in.
Length of tender over bumper beams	22 ft 4 in
" " tank	19 ft. 6 in.
Width " "	9 ft 10 in.
Height of tank not including collar	3 ft. 10 in.
Type of draw-gear	M. C. B. Standard.

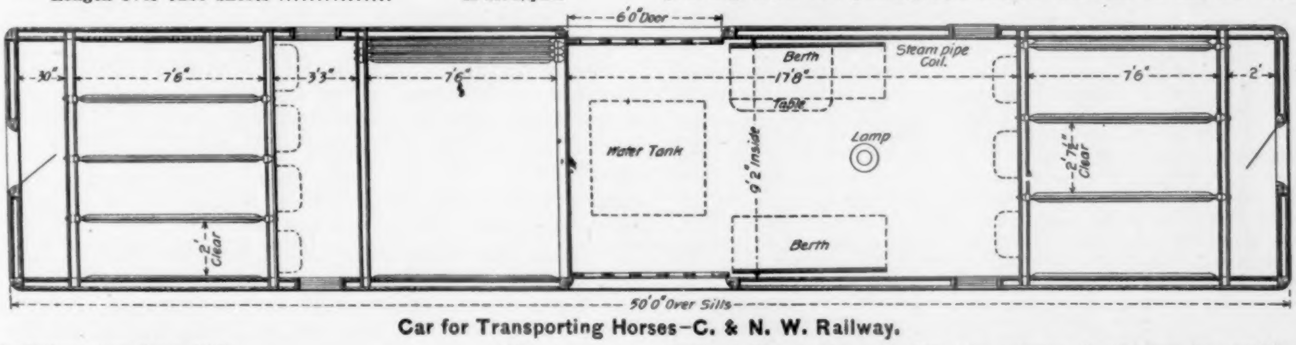
Special Equipment.

Brakes	Westinghouse-American for engine, tender and train.
Pump	9½ in. Westinghouse.
Bell Ringer	Golmar.
Sight Feed Lubricators	Michigan and Nathan.
Safety Valves	Crosby
Injectors	Hancock No. 8, Monitor No. 9 and Metropolitan No 8.
Springs	A. French Spring Co.
Blow-off cock	McIntosh.
Tires	Krupp.

CAR FOR TRANSPORTATION OF HORSES, C. & N. W. RAILWAY.

The car shown by the accompanying engravings is constructed as a baggage car and intended for transporting horses and the fittings are so arranged as to permit of the use of the car for baggage or other purposes, the partitions and special equipment of the car being stowed out of the way, when necessary. We have received the drawing and photograph from Mr. C. A. Schroyer, Superintendent of Car Department of the Chicago & Northwestern Railway. The car is known as the "Northwest." It is 50 feet long over the end sills, 9 feet 10 inches wide, 14 feet high from the rail to the top of the deck, 49 feet 4 inches long inside and 9 feet 2 inches wide inside. Iron cross beams receive movable stanchions carrying partitions forming the stalls and these may be moved to one side along the cross beams, as indicated in the drawing. The engraving from the photograph shows one end of the car with four stalls, made up with the canvas feed bags in position, while the drawing shows the plan of the car, giving the chief dimensions. Stable room for 12 horses is provided, the stalls are made adjustable so that the width may be changed even to the extent of providing three box stalls. The sides, ends, roof and floor are insulated with paper, the car has passenger platforms, 6-wheel trucks, air brakes, air signal and steam heating appartus. A 100-gallon water tank is secured to the roof of the car with pipe connections to a sink hinged to the side of the car, so that it may be folded up out of the way. A table is also hinged to the side of the car for folding up when not in use. Canvas collapsing sleeping berths for two men are provided and a tool and a hay box are carried underneath the car floor.

View of One End of Car.



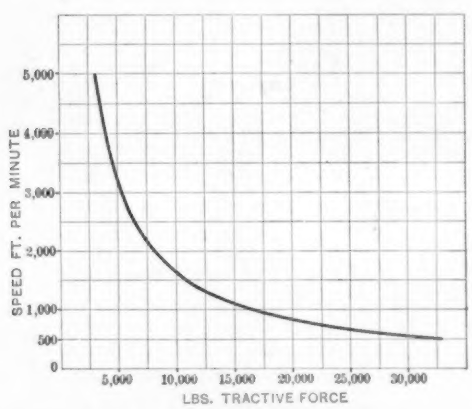
Car for Transporting Horses—C. & N. W. Railway.

THE WAR RELIEF FUND.

One million dollars is to be raised for the work of the American National Red Cross, of which Clara Barton is president, and of the Central Cuban Relief Committee, appointed by the President of the United States. Our assistance has been asked by the publishing house of Funk & Wagnalls Company, who have generously undertaken to aid in the collection of money which we understand is to go directly to the relief work, absolutely without any deductions or commissions. Money sent to our publication office, Morse Building, New York, will be promptly forwarded to Funk & Wagnalls, who will send a copy of the lithograph, "The Accolade," to those who donate $1.

THE HORSE POWER OF LOCOMOTIVES.

The usual method of rating the power of locomotives by the tractive force at full stroke is useful only for starting conditions and at very slow speed. While it may be a convenient figure for comparing the power of different locomotives in a rough way, it is of little use in determining their power under working conditions and average speed. The important thing in locomotive design is to select proportions so as to secure the best possible results under the conditions with which most of its work is done. It has taken a long time for us to realize that starting power is not the most essential thing, and that the best working proportion need not be made for that stage of operation. This is well illustrated by valve proportions. Until recent years lead was always stated at full stroke and little consideration was given to what it might be, or what its effect would be at the regular working cut off. It is now the custom in best practice to pay particular attention to lead in average cut off, and secure the best steam distribution at that point. In like manner we are awakening to the fact that economical working requires that the locomotive should do its best work at the average running speed and that the greater the power obtained at such speed (without sacrificing essentials at other speeds) the more efficient will be the machine. We have, then, to consider the combination of tractive power and speed or horse power which is measured by 33,000 foot pounds per minute. The fact that tractive power decreases with speed and



Curve for 500 Horse Power.

cut off, while taken account of in a general way, has not been thought important enough to necessitate determining, in many cases, the rate at which that decrease takes place.

The study of indicator cards for this purpose, and the combination of the tractive power thus found at different cut offs, with the speed, making a horse power curve, has rarely been resorted to. We may therefore describe this new method of rating locomotives, as the "horse-power curve." This curve, will, of course, vary with different combinations of cylinders, boiler pressure and wheels. The theoretical curve can easily be drawn for any horse power by plotting the speed upon the tractive power, as in the accompanying diagram. Then by means of indicator cards at different working cut offs with the speeds carefuly noted, the tractive power at different speeds is obtained. For this purpose, an accurate speed recorder is necessary, and the cut offs in even inches should be marked on the reverse quadrant. The tractive power multiplied by the speed of the engine in feet per minute gives the horse power for different speeds, and this when plotted on the same sheet with the theoretical curve will show at a glance how near the actual performance of the engine approaches in practice to the theoretical power. It will show also, if there is a departure from the theoretical curve at working speed, that it may be desirable to make some change in the size of cylinder or wheels.

In working long grades and in running passenger trains at high speeds with long intervals between stops, it is necessary that the maximum horse power of the locomotive shall be sustained for long periods, and under such conditions any weak points of design, either of engine or boiler, will be shown. When analyzed into its component parts the horse power for any given engine has two principal variables, one the speed which is independent of the design, the other the tractive power, which depends not only on cylinders and wheels, but also on the boiler. With cylinders and wheels given, the tractive power depends principally on the mean effective pressure in the cylinder, and for high tractive power the aim therefore should be to obtain the highest possible mean effective pressure. The highest mean effective pressure is only obtained by the best proportion of valves and ports and the best valve motion. It also depends upon continuous full boiler pressure.

In using indicator cards for horse power curves, it is therefore important to select those taken under such working conditions as will enable the engine to maintain full boiler pressure. To obtain this under maximum load requires good boiler design with best proportions for grate and heating surfaces. It will be seen from this that the maximum horse power in a locomotive involves nearly all there is in the best design for both engine and boiler, and it thus becomes a very good measure of the true value of the locomotive as a hauling machine. Measured in this way we may say that for any given type of locomotive having proper driving wheel adhesion, that one is the best which develops the greatest horse power at the normal working speed for each ton or pound of total weight of engine. If we take E to represent this kind of efficiency, and W the weight of the engine, then $E = \frac{H\ P}{W}$.

This presentation may appear to be very simple and elementary, but it will serve as an introduction to a method which will be found very useful in determining the proper proportions for locomotives intended for heavy grade work at slow speeds as compared with those in ordinary service at medium speeds, and also for passenger locomotives which must sustain high speeds for long distances.

THE HORWICH LOCOMOTIVE WORKS OF THE LANCASHIRE & YORKSHIRE RAILWAY, ENGLAND.

By William Forsyth.

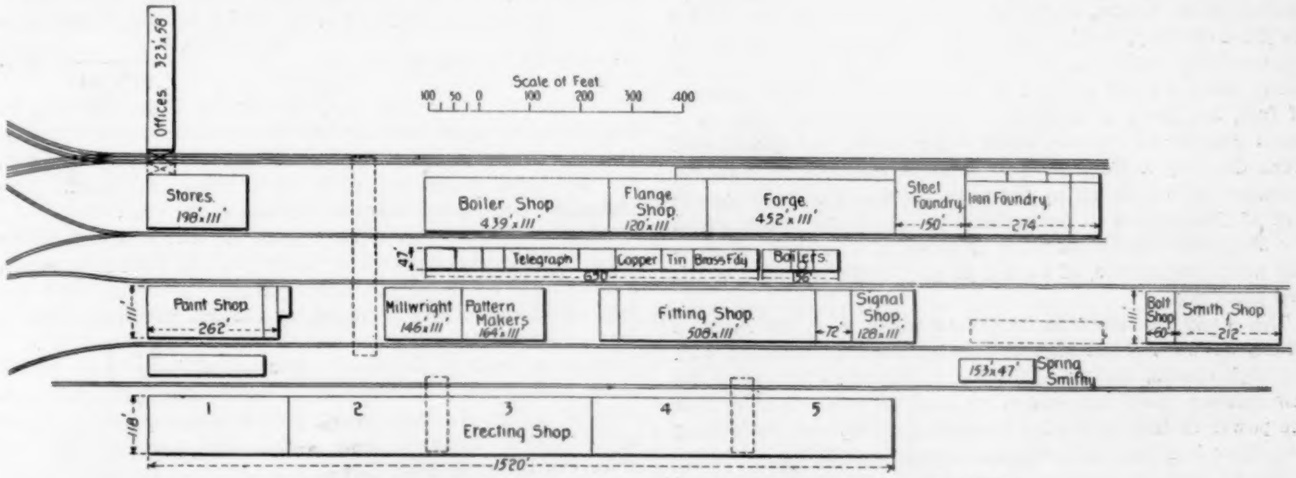
Although the Horwich shops are the largest locomotive repair shops in the world, they are comparatively unknown to most American master mechanics, and a general plan of the works and a brief description of the principal departments will probably prove interesting. The buildings were commenced in 1886 and the shops were in running order in June, 1889, at the time the American engineers visited England. The contingent which was fortunate enough to visit Horwich at that time has not yet ceased to marvel at the vast extent of the works and the substantial character of the buildings. The plant was entirely completed in 1892.

To the present Chief Mechanical Engineer of the road, Mr. J. A. F. Aspinall, was assigned the duty of superintending the erection of the works, the arrangement of the machinery, and starting them as a working establishment. The land inclosed for the works includes 85 acres and the covered area of the shops is 13½ acres. In addition to the ordinary 4 feet 8½ inch gauge railway connecting the various parts of the works there is a narrow 18-inch gauge railway traversing every part of the plant, its total length being 6½ miles. It is worked by small locomotives, with trains conveying materials and finished work between the several departments. An open passenger car with seats, back to back, is also used on this line for the convenience of visitors and officers.

The main line of the Lancashire & Yorkshire Railway runs east and west across England, and is only about 300 miles long, but it has numerous branches. The equipment consists of over 1,000 locomotives, and they are all renewed or repaired at this one shop. All other iron and steel work for the line, except cars and bridges and rails, is manufactured here. The plant is remarkable for the number and size of the buildings, there are twenty different departments, and ten of the large shops have a uniform width of 111 feet. Some of the products of the establishment are unusual in railroad shops abroad, and are never found connected with American railroad shops. These are the large steel foundry, a 14-inch merchant rolling mill, an 8-inch guide mill and a chain shop. The office is 323 by 58 feet, two stories high, and besides the accounting offices, contains a large drafting room and a testing room and laboratory. The storehouse is also a two-story building, 198 by 111 feet, the second floor having a gallery, leaving a light well at the center.

The boiler shop is 439 by 111 feet, arranged in three bays, the first for building and repairing boilers, the second for tenders, tanks and miscellaneous sheet iron work; the third for tools, drills, punches, shears, etc., and each bay is provided with an overhead traveling crane. The rivet furnaces are heated by oil, sprayed by compressed air. At the end of the shop the roof is carried up 16 feet higher to form a riveting tower. The flange shop, adjacent to the boiler shop, is 120 by

111 feet, and contains hydraulic flange presses for boiler heads, tube plates, etc., gas furnaces being used for reheating plates. The forge is 452 by 111 feet and is located next to the foundries, on account of a side hill which provides an upper level for the gas producers and charging platforms. The natural formation of the ground at this point is 14 feet higher than the rail line of the shops. The forgings are heated in gas furnaces, the scrap being cut up on the high level and taken by power conveyers to the furnaces. This building contains the 12-inch and 8-inch rolling mills. The smaller smith forging is done in several other buildings. The flange shop contains several forges for boiler forgings. The large blacksmith shop or smithy, as it is called, is 212 by 111 feet, containing 33 single forges and 11 double forges. The bolt shop, 60 by 111 feet, contains bolt, nut, rivet and nail machines, as well as drop hammers for die work. The spring shop, 153 by 47 feet, has two gas spring furnaces and hydraulic spring machinery.



Ground Plan, Horwich Shops—Lancashire & Yorkhsire Railway, England.

The steel foundry, 150 by 135 feet, contains one 20-ton and two 10-ton Siemens-Martin regenerative melting furnaces, heated by gas from their own series of gas producers. When a railroad is provided with its own steel foundry, the tendency is to substitute steel castings for forgings in locomotive details as far as possible, and the extent to which this has been done on the Lancashire & Yorkshire is shown by the constant use of so large a steel foundry. Steel centers for driving wheels and centers for steel tired wheels for trucks are among the heavier castings produced.

The iron foundry, 212 by 111 feet, is used for general castings, not only for locomotive work, but for cars and roadways. The wheel shop, 165 by 47 feet, is near the foundries, and contains wheel boring mills and lathes. The passenger car wheels are put together in this shop, and a special hydraulic press is provided for forcing the wood blocks between the wheels centers and the tire. It is not so long ago since the locomotive driving wheels on the Fort Wayne road were built up in this way, but the hickory blocks were driven in by sledges.

The boiler house, 156 by 47 feet, contains two nests of five boilers each. These are connected with two sets of Green's economizers. The only use for electricity here is for light and an engine and dynamos supply light to one end of the works and also to the offices.

A series of long, narrow buildings, 47 feet wide, contain the brass foundry, 105 feet long, tinsmith, 150 feet; coppersmith, 90 feet; tube cleaning and case hardening, 75 feet; telegraph shop, 153 feet; a special shop, 128 by 111 feet, is provided for the manufacture of signals, and another, 72 by 111 feet, for frogs and crossings. We now come to the two principal shops, the machine shop, marked on the plan as the "fitting shop," and the erecting shop.

The machine shop is 508 by 111 feet. It has cross-track communication with the erecting shops and is provided with a walking crane for handling heavy pieces to the machine tools. There are four lines of shafting running the length of the shop and driven by two wall engines at one end. A series of tools are employed in finishing cylinders, and a number of large milling tools, both vertical and horizontal, are provided for finishing rods and valve motions. Other portions of the shop are devoted to brass finishing, a tool room, and at one end are the rod gangs and work bench fitting, where the small amount of necessary hand work is done. The shop is heated by pipes in trenches covered with chequered gratings, which also serve for the narrow gauge tracks, grooves being cast in them for this purpose. The artificial light is afforded by inverted arc lamps under large white painted wood disks suspended from the roof trusses.

The erecting shop is the most remarkable of all the buildings, on account of its great length. It is 1,520 feet long and 118 feet wide, and has a capacity of over 100 locomotives at one time. It is divided into two large bays and one smaller bay in the middle of the shop. The outside bays are used for repairs and renewals of locomotives, the small middle bay being used for fitters' benches and for small tools, such as drills, placed at suitable positions along the shops, and for the storage of materials. The erecting shops are divided into Nos. 1, 2, 3, 4 and 5 respectively. The No. 1 shop is used for the erecting of new tenders and repairing of existing stock. Of No. 2 shop about one-quarter is taken up for boiler mounting; the boilers being received from the boiler shop are here fitted with tubes and the brass mountings; they are also tested both with water and steam before being sent to the erectors; the other three-fourths of the shop are taken up with general locomotive repairs. Nos 3 and 4 shops are exclusively used for locomotive repairs. No. 5 shop is mainly used for locomotive repairs, but a small portion is set apart for new work. Each outside bay of each erecting shop is provided with two 36-ton overhead traveling cranes, making twenty in all. Wheel lathes are provided at various parts of the erecting shops for dealing with the wheels taken from the locomotives under repair. A number of portable hydraulic riveters are also provided. Access for locomotives to the center portion of the shops is provided by two traversers, or transfer tables. As the machine shop, boiler, flange, and erecting shops have the same width, their area is proportional to their length and we find that the total length of the boiler and flange shops is about 50 feet longer than the machine shop, and the erecting shop is about three times the size of the machine shop.

Much as we may boast of our American railways and locomotive shops we have nothing in this country to be compared with the Horwich shops as locomotive repair shops. A visit to them is an inspiration, and only by seeing them can one get an idea of the vast plant which is necessary for the maintenance of the machinery of a large railroad having a dense traffic.

LOCOMOTIVE CHARACTERISTICS.

By G. R. Henderson, Mechanical Engineer Norfolk & Western Railway.

At the present stage of railroad development, when all efforts are turned toward the economical construction and operation of equipment, the locomotive has naturally come in for its share of study, and its power and efficiency have been freely discussed and criticised. Economical operation does not necessarily mean a great amount of work done by a small amount of fuel, but more frequently, a great amount of work by a small number of engines, or in other words, the quantity of work done by a locomotive is of more importance than the economy of fuel shown by the same locomotive. It is the object of this article to determine the conditions under which the maximum amount of work or power can be obtained from any given locomotive, of known proportions, regardless of the fuel economy.

The study of indicator diagrams taken from locomotives clearly shows that the highest horse-powers are obtained with the high speeds, and we shall first endeavor to determine the law between speed and power. It must be borne in mind that the power of the locomotive is determined by the boiler, and that there is a limit to its steam producing capacity.

Let us first produce an equation between the amount of steam supplied by the boiler and that used by the cylinders, and consider that:

v=volume of both cylinders, in cubic feet (this refers to simple engines only);

b=ratio of grate area to cylinder volume (square feet to cubic feet);

c=maximum rate of combustion in pounds per square foot of grate area, per hour;

d=evaporation rate under the assumed conditions, from and at 212 degrees.

Then the maximum quantity of steam which the boiler can supply in pounds per hour,

$= v \times b \times c \times d$, from and at 212 degrees.

(The values of these factors under different conditions may be obtained from the report on "Grate Area and Heating Surface," made last year to the Master Mechanics' Association, see page 218 of the proceedings for 1897.)

Let x=cut-off ratio in the cylinders;

y=revolutions per minute;

a=weight in pounds of a cubic foot of steam at cut-off pressure;

then, allowing 1.2 for the factor of evaporation (from 212 degrees to working pressure), and 25 per cent. for cylinder condensation, we have the weight of steam used per hour, in pounds;

$= v \times x \times 2 \times y \times a \times 1.2 \times 1.25 \times 60$, from and at 212 deg.

Equating, and canceling out v on both sides, we have $x \times y \; 2 \times a \times 1.2 \times 1.25 \times 60 = b \times c \times d$, and

$$x\,y = \frac{b \times c \times d}{2 \times a \times 1.2 \times 1.25 \times 60}$$

which is the equation of an hyperbola, referred to its asymptotes as axes.

If we assume the values for a, b, c and d = 0.284, 3, 160 and 6 respectively, we have

$$x\,y = \frac{3 \times 160 \times 6}{2 \times 0.284 \times 1.2 \times 1.25 \times 60} = 56.33$$

illustrated by the curve A-A, of Fig. 1. This line will be understood to show the latest cut-offs that the boiler will supply with steam at the various speeds shown by the abscissae, the ordinates representing the proportion of cut-off. The valve gear prevents a later cut-off than 90 per cent.

We now proceed to construct a curve, which will give the "maximum mean available pressure" for the different speeds, and by this we mean the mean effective pressure, with the friction of the engine deducted, or the net effective pressure on the pistons.

Diagram No. 2 of the Master Mechanics' Association report above mentioned [this diagram is reproduced here as Fig. 3, and Fig. 1 from the same report is reproduced as Fig. 4. They will be found also in our issue of July, 1897, page 251.—Editor] gives the ratio of mean effective pressure to initial pressure for various speeds and cut-offs, and allowing in addition 5 per cent. drop from boiler pressure to initial pressure, and 8 per cent. for engine (internal) friction, we have the results of the diagram multiplied by 0.95×0.92=say 0.88, with which to construct the line B-B, which shows the maximum mean available pressures which can be obtained at the various speeds. This allows for the internal friction of the engine, but not for the journal and rolling friction.

It is to be noted, that a strict interpretation of the line

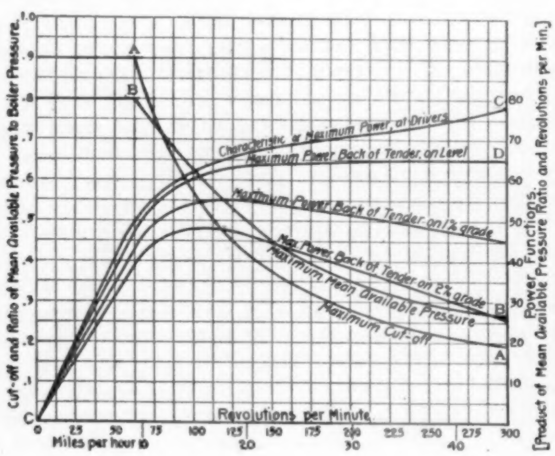


Fig. 1.

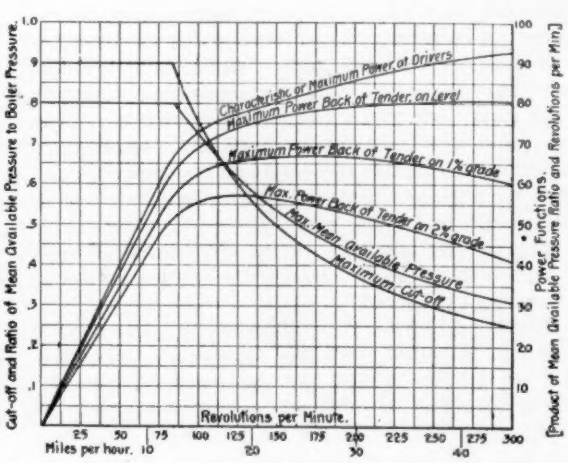


Fig. 2.

A-A of maximum cut-offs, would require the left-hand end to be slightly dropped, as at slower speeds, the cut-off pressure and weight of steam would be greater, and therefore reduce the permissible cut-off, but other authorities indicate that the hyperbola can safely be used.

As the tractive force of a locomotive is expressed by the formula $\frac{p\,d^2\,S}{D}$ where p=mean effective pressure in pounds per square inch; d=diameter of cylinders in inches; S=stroke in inches; D=diameter of drivers in inches; the tractive force will be a function of the ordinates to the curve B-B, and will therefore vary as, or be proportional to, these ordinates. This shows that the tractive force is a maximum at low speeds.

The work or power developed by a locomotive is the product of the tractive force and the speed, and as we have just shown that the tractive force is proportional to the ordinates of the

curve B-B, the work done will be proportional to the product of the ordinates and abscissae of the curve B-B. This is represented by the curve C-C, which has been produced simply by multiplying together the co-ordinates of B-B, and laying off the product on the corresponding abscissae as ordinates. This curve we call the "Characteristic of the Locomotive."

It is interesting to note how this line rises, rapidly until the capacity of the boiler is reached, when it assumes a nearly horizontal direction, rising more rapidly, however, at high speeds. This gradual rise is probably due to the economy of using steam at shorter cut-offs. In reading the numerical values of this curve, be governed by the values at right side of diagram. Of course the line C-C must be understood as showing the ratio of power at the circumference of the drivers.

The point of greatest interest to the transportation department is, however, the power back of the tender coupler, or, with the proper allowances for the resistance of the engine and tender. C-D has been formed by subtracting from C-C, the power necessary to move the engine and tender at the speed in question, on a level track, the resistance due to speed being taken from diagram No. 1, of the Master Mechanics' Report, above referred to, shown here in Fig. 4. For allowances for grades of one and two per cent., the additional deductions have also been made, and the corresponding curves produced. The values to be deducted bear the same ratio to the resistance of the engine and tender, as the curve C-C does to the total power of the engine.

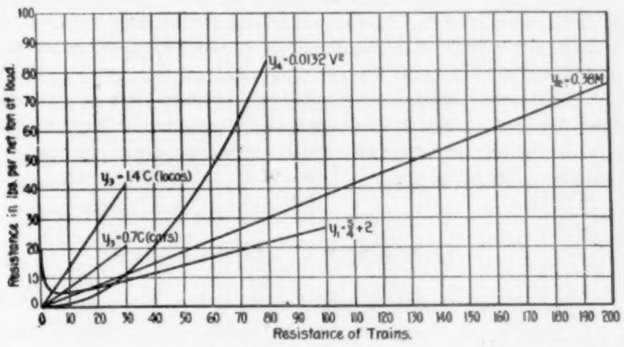


Fig. 4.

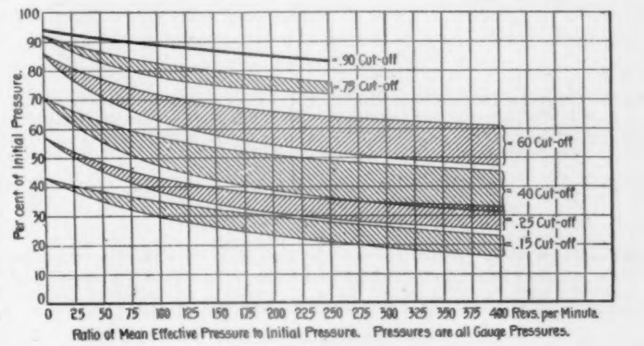


Fig. 3.

In making these deductions it has been assumed that the locomotive in question has 20 by 24 inch cylinders, 50 inch drivers, and weighs 100 tons complete with tender.

From these various curves we conclude that:

1st. The power at the drivers increases with the speed, although it remains nearly stationary at velocities near 200 revolutions per minute.

2nd. The power or work done back of tender reaches its maximum at a speed of 20 miles per hour, or 135 revolutions per minute, and remains constant for increasing speeds, when working on a level.

3rd. The power or work done back of tender is a maximum at about 18 miles per hour, when working on a 1 per cent. grade.

4th. The power or work done back of tender is a maximum at about 15 miles per hour, when working on a 2 per cent. grade.

5th. Omitting the question of speed, and also work or power, the maximum tractive force is developed at speeds of 10 miles per hour and less.

Of course it must be remembered that these results pertain only to an engine of the proportions assumed for the present case, and that every engine to be considered in this way should have its proper curves laid out.

By referring to the first formula, it can be readily seen how a change in any of the vital dimensions or proportions will affect the curves. For instance, let us assume that "b," the ratio of grate area in square feet to the total cylinder volume in cubic feet, shall be 4 instead of 3, or the grate to be one-third larger, with the proper proportion of heating surface, but same total weight of engine and tender. Now it is evident that one-third more steam would be produced, and therefore the hyperbola A-A, instead of being represented by the equation $xy=56.33$, would be expressed by the equation $xy=75.11$. This curve, with its mates as before explained, is shown in Fig. 2. It will now be seen that as a result of the additional steam advantages, the maximum points are much greater in power, besides exerting these maxima at increased speeds. For instance, at a level the maximum work or power back of tender is found at speeds of 30 miles an hour and upward; on a 1 per cent. grade, at 25 miles per hour; and on a 2 per cent. grade, at 20 miles per hour. This is the direct advantage of having a boiler of greater capacity, and its lesson cannot be ignored.

The foregoing remarks are merely intended to introduce the method of analyzing a locomotive by its characteristic, which may be determined in advance even of its design, provided that the leading dimensions and proportions are given or assumed. While we believe this method of treatment to be original and somewhat radical, it may, we think, be used to good advantage in many cases, especially where the most economical conditions of operation are being studied.

HEATING FEED WATER WITH LIVE STEAM.

That it will pay to take live steam from a boiler to heat the feed water of the same boiler is very difficult for many to accept, but we may "believe one who has tried it."

"The Engineer" in reporting a recent meeting of the Institution of Naval Architects quotes Prof. Unwin as having found a saving of 15 per cent. in one case, by the use of live steam to heat feed water. For some time he was puzzled for an explanation of this apparent absurdity, but finally made up his mind that when water at boiling temperature comes into contact with the heating surface of a boiler it takes up heat more readily than cold water and in one case he found the temperature of the gases in the chimney to be reduced by a very hot feed, all other conditions of running remaining unchanged.

For many years it has been known that the transmission of heat through a receptacle containing boiling water was much more rapid than when the water was being raised to the boiling temperature and the reason appears to be found in the improved circulation on movement of the water.

Laboratory experiments are quoted by "Engineering" showing that where water is caused to move briskly over a heated surface, the rate of heating may be five times as great as when the water is left at rest and the further observation is made that the temperature of the water surface of a plate may be considerably more than that of the water nominally in contact with it, giving "the paradoxical result that this temperature may be less when the water is hot than when it is colder, provided that the circulation is more brisk with the hotter water." Mr. Macfarlane Gray, who has recently brought the subject into attention again, states that all of the heat that is transmitted through boiler plates should be put into the evaporation of the water and should not be used to raise it to the boiling point.

Whether this idea is new or old does not matter. It is very interesting and probably will play an important part in connection with steam engineering in the future. Some very progressive people are still a little skeptical and it can do no harm to urge that the subject be investigated very carefully. Those already using the principle will learn more about it and the skeptics may learn something also.

(Established 1832.)

AMERICAN ENGINEER CAR BUILDER AND RAILROAD JOURNAL.

29TH YEAR. 67TH YEAR.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE,

MORSE BUILDING .... NEW YORK

G. M. BASFORD, Editor.

JUNE, 1898.

Subscription.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Universal Postal Union.*
Subscriptions for this paper will be received and copies kept for sale by the Post Office News Co., 217 Dearborn Street, Chicago, Ill.

EDITORIAL ANNOUNCEMENTS.

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Special Notice.—*As the* AMERICAN ENGINEER, CAR BUILDER AND RAILROAD JOURNAL *is printed and ready for mailing on the last day of the month, correspondence, advertisements, etc., intended for insertion must be received not later than the 20th day of each month.*

Contributions.—*Articles relating to railway rolling stock construction and management and kindred topics, by those who are practically acquainted with these subjects, are specially desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

To Subscribers.—*The* AMERICAN ENGINEER, CAR BUILDER AND RAILROAD JOURNAL *is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper ought at once to notify the postmaster at the office of delivery, and in case the paper is not then obtained this office should be notified, so that the missing paper may be supplied.* **When a subscriber changes his address** *he ought to notify this office at once, so that the paper may be sent to the proper destination.*

The paper may be obtained and subscriptions for it sent to the following agencies: **Chicago,** *Post Office News Co., 217 Dearborn Street.* **London, Eng.,** *Sampson Low, Marston & Co., Limited St. Dunstan's House, Fetter Lane, E. C.*

The troublesome question of "wrong repairs," in the interchange of freight cars, has caused a great deal of discussion since the last convention and it now seems probable that the Master Car Builders' Association will take action to remedy the present difficulty with regard to neglect of the repair card. If intermediate roads are held responsible for the application of M. C. B. repair cards the trouble will be remedied because this will permit of locating the road making wrong repairs.

The narrow limits allowed by law for the height of couplers renders it necessary to provide convenient means for adjusting the height of cars after they have been placed in service. Several methods have been used, but one of the most convenient is that shown in the illustration of the new Lake Shore coal cars on another page of this issue. Wooden blocks are placed under the ends of the truck bolsters and above the springs. By varying the thickness of these the necessary adjustment may be made by simply raising the bolster off the springs.

It is not uncommon practice to increase the boiler capacity of old and comparatively small locomotives in rebuilding them and besides adding to the heating surfaces and the grate area, the new boilers are often built for higher pressures, all of which increase their capacity for doing work. The remarks of Mr. F. R. F. Brown in regard to rebuilding locomotives, which will be found elsewhere in this issue, and also the ingenious, novel and valuable power comparisons made by Mr. G. R. Henderson in his article on "Locomotive Characteristics" tend to show the importance of large boiler capacity. Large boilers do not require as much forcing as small ones, for the same work, which may be expected to show favorably in the returns, but, as Mr. Henderson says, "The quantity of work done by a locomotive is of more importance than the economy of fuel shown by the same locomotive." High boiler power offers a double reward, an increased capacity for work and a more favorable rate cost for the work done. The numerical values for the increase in power with an increase in the vital dimensions and proportions which Mr. Henderson presents and the analysis of the locomotive by its characteristic before the construction is begun are full of interest and suggestions to locomotive men. The time is at hand for serious consideration of every possible factor contributing toward increasing the power of the locomotive and the analysis is commended as furnishing an "X-ray" view of the capabilities of an engine before it has been laid down even on paper.

LOCOMOTIVE TRUCK BRAKES.

The locomotive truck brake as an aid in stopping trains was the subject of discussion at the recent convention of the Air Brake Men's Association in Baltimore. This matter has been before the railroads for a long time and while the advantages obtained by the additional braking power are very great little progress has been made in applying them to engine trucks. There seems to have been no good reason why they have not been used more generally, unless the pressure brought to bear in connection with freight equipment has for a time caused a diversion of attention from these trucks. Mr. George Westinghouse six years ago directed attention to the fact that the locomotive, if fully braked, is capable of exerting four times the amount of retarding influence for each pound weight per wheel given by any other vehicle in the train with the exception of the tender, and in connection with this it is important to remember that the braking power of the locomotive does not vary with the loading, as is the case with cars. It is well that this subject should be kept in mind and after the requirements of the law in regard to car equipment have been fulfilled, the truck brakes will undoubtedly receive the consideration that is due them.

COMPETITIVE TESTS OF LOCOMOTIVES.

Some time before the Liverpool & Manchester Railroad was publicly opened, in 1830, the question of motive power naturally came before the directors, as it was then necessary to arrange to work the traffic on the road either by animal or some other kind of power. They employed eminent engineers to visit and inspect all the railways then at work, but from the reports which were made to the directors they did not feel able to come to a decision. It was, therefore, proposed to offer a reward, or premium, of £500 for the best locomotive engine which should draw a load equal to three times its weight at a given speed, and it was stipulated that the weight carried on four wheels of the engine should not exceed 4½ tons=10,080 pounds, or 2,520 per wheel. The trial, we are told, "was to take place on a 1½ miles stage, with one-eighth of a mile extra at each end for starting and stopping, and to consist of twenty double trips." "Each locomotive was required to run ten trips over the trial ground, equal to a journey of thirty-five miles, at full speed, the average rate to be not less than ten miles per hour. At the end of the first ten trips each engine was to be got ready again, and to repeat the test,

the object being to prove that the engine would be able to perform a journey from Liverpool to Manchester and back." Three historic locomotives were entered for the competitive test, the object of which, as stated, was to ascertain the best locomotive "to work the traffic" of the new line.

It often happens that the dictionary is very suggestive in indicating the force or scope of an idea. Now, one of the definitions of "competition" is "strife for superiority." It was the purpose, evidently, of the directors of this pioneer road to produce a "strife for superiority" among inventors, mechanics and engineers in the design and construction of locomotive engines. For the accomplishment of the end which they had in view, as was shown by subsequent events, it was essential that there should be competition. Stephenson adopted the multitubular boiler in his locomotive "Rocket," but we are told "after some preliminary trials, previous to the commencement of the competition, during which the superior evaporating power of the 'Sanspariel,' with a sharp blast from the exhaust directed upward into its chimney, became apparent, it was resolved to discharge the exhaust steam of the "Rocket" into the chimney; and, on the eve of the first day of the trial, the exhaust pipes were diverted into the chimney with an upward termination." It was this change, combined with the multitubular boiler, which enabled the "Rocket" to win the prize.

It was at this time of the utmost importance to the directors of this road that they should know what kind of motive power would be the most economical and efficient for the traffic of the line. This same question is of equal, and, in fact, considering the extent of the interests involved, of much greater, importance to the directors of our great railroads now than it was then. It is true that we have had sixty-eight years of experience in the construction of locomotives since then, in which time they have been developed from puny little asthmatic iron insects—they might be called—to mighty beasts whose tread literally shakes the earth, whose shrieks are echoed from mountain top to mountain top, and whose power is limited alone by the laws of nature. We have the precedents and practice of half a century or more to guide us in their construction, but even with this flood of light and knowledge there is still much difference of opinion among those most competent to be the mechanical guides, of boards of directors and railroad managers. In other words, the question which are the best locomotives? is as much a live one to-day as it was when the Liverpool & Manchester trial was proposed.

It is of course true that most railroads have and are making tests to ascertain which are the best, most economical and efficient locomotives for their traffic. Many of them employ experts who are possessed of varying amounts of knowledge and ignorance, and who subject locomotives to trials of different kinds. Some roads and educational institutions have testing laboratories especially adapted for making trials of locomotives, where the utmost refinement of experiment and observation is possible. The point to which special attention is called here is that in nearly or quite all such tests the competitive element is absent, and, what is perhaps worse, there is naturally and of necessity a bias of prejudice and interest to refract the conclusions drawn from true logical verity. A very common case may be cited. A locomotive superintendent designs and builds a locomotive, or prepares the specifications and decides upon the plans on which they shall be built. When completed, if he should test one or more of them, could we expect that he would report any serious deficiencies in such machines to his superior officers, no matter what the defects should be? It might be worse than that even, for under such conditions probably few men would be able to recognize any defects. During many years' intercourse with master-mechanics on railroads it was a very common experience of the writer to interview men in such positions who had built locomotives from their own designs. In nearly all such cases, when the new engine was exhibited to the interviewer the builder would proclaim, with uplifted arm, as though he was about to make oath to the assertion, that "that is the best locomotive that ever turned a wheel," and they generally believed what they said. Now, under such conditions, if a master mechanic should test his engine is it at all likely that he would admit that its fire box was too small, its heating surface insufficient, that it had not enough steam space, and worked water, or its weight was improperly distributed. We all know he would not.

In their perplexity the directors of the Liverpool & Manchester railroad employed experts to indicate to the company what would be the most efficient motive power to employ. The most eminent of these engineers recommended that they should adopt rope traction. If they had not resorted to a competitive test the advice which they would have had to guide them would probably have been very much like that some of the superior officers of our railroads of to-day get from their experts, who spend months in figuring over the significance of vast multitudes of "variables" which are observed in highly scientific experimental tests of locomotives, on their own lines, in which there is usually "no strife for superiority."

Let us suppose a case: The traffic of a railroad has increased and an addition to the motive power is required. It will be supposed that at certain times of the year it has a heavy passenger traffic, which falls off materially—as it does on many lines—in midwinter, and at other times. It is essential that engines for this traffic should be able to pull heavy loads at some seasons, and that they should work economically when the trains are lighter. Now, supposing that under these conditions a railroad company was about to order, say ten new engines, and the question should arise, what kind would be best suited for the requirements of such traffic, what would be the natural course of the inquiry? The condition and character of the road bed and rails would limit the loads which should be carried per wheel, as it did on the Liverpool & Manchester road. On a well ballasted line laid with heavy rails, it is now considered admissable to load each of the driving wheels with 20,000 pounds. If four wheels thus loaded would give sufficient adhesion and traction to pull the heaviest trains, then the general plan which would probably be specified, would be either the American, Columbia or Atlantic type of engine, the weight of which would be limited to about 120,000 pounds each. Those in authority would then want to know first the relative first cost of engines of such a weight of the several plans; second, which would haul the trains with the greatest regularity and promptness and the least consumption of fuel and lowest cost of repairs; and, third, which would perform the maximum amount of service in a given time, say a year, or a number of years. Evidently this was the sort of information the directors of the Liverpool & Manchester railroad were after, and it is the kind of knowledge about locomotives that general officers and directors want now when they are about to increase their motive power. The quantity of water evaporated per pound of coal, the temperature in the smoke box, the precise form of indicator diagrams, which the engine will make, or its consumption of fuel per horse power per hour are all matters of indifference to them. What they want most to know is which kind of engine is most certain to pull the trains on time from day to day and year to year, and next—but this is of secondary importance—which will do it with the least cost of fuel and expense for maintenance? Of course it is true that the reliability of a locomotive can only be demonstrated by actual service, but the relative reliability of several classes could be very clearly indicated by a competitive test.

The point which it is intended to bring out here is that a test which is not competitive proves very little. If an American locomotive runs on the A. & B. road and one of the Columbia type on the C. & D. line, it is usually impossible to tell which would have rendered the best service if each had been tried on the same line. There is also another phase of what may be called ex parte tests, and that is that it is almost impossible to prevent those who are in charge of the experiments from showing undue favoritism to the engines tested. Many employees consider it their duty to lie and cheat in their em-

ployers' interest. Most sporting men would regard with derision an attempt to determine which of a number of horses was the fastest by a trial of speed of each separately and on different tracks. And yet that is what is done when we undertake to determine the speed and endurance of locomotives.

What is suggested here then is that competitive tests of locomotives should be made under the auspices and direction of a committee of the Master Mechanics' Association, the main object of such tests being, as mentioned before, to ascertain what kind of locomotive is the best adapted for a certain kind of traffic.

The course of procedure and the aims of such a movement would be, first, to have a committee of say five members of that association to formulate a plan of making the tests and have charge of and direct how they should be made. The committee should consist of several members of the hard-headed, practical type, who have had long experience in their occupations, and two who, besides ample experience, have had the advantages which technical educations give them, and perhaps an experienced designer of locomotives. Now, as such men would in all probability be actively engaged in the performance of their duties on different railroads, it could not be expected that they could give the time required to personally conduct a series of experiments which, in all probability, would occupy weeks or months. The committee would therefore require to employ some competent person to take charge of the experimental work, and he would need an assistant. The committee would, however, after the most careful deliberation, determine the scope and nature of the investigations, and specify in detail how they should be made. The person or persons employed would act under the direction of the committee, and would report to the latter. As probably no competent person could be found to take charge of such work who would be willing to give the time to them which would be required without compensation the mechanical expert and his assistant would have to be paid. This would imply that some money must be provided for such, and some few other expenses. The committee should therefore be authorized to raise and expend money for the purpose contemplated, with the usual powers and responsibilities of an auditing committee.

Some years ago a somewhat similar measure was proposed and acted upon by the Master Mechanics' Association, and one committee was then appointed to solicit and raise money and then hand it over to another committee—over which the first one had no control—to expend. Some of the members of the ways and means committee very properly objected to incurring the responsibility of soliciting money without authority to control its disbursement. The persons who secure the money for such tests should have the control and the responsibility for its expenditure.

The investigations, in the beginning, should be directed to the solution of some very practical problems alone, and should be devised to indicate simply which of a number of locomotives will perform a given service most effectually and at the least cost. The tests should therefore be made in actual service. The method of making them may be suggested:

An arrangement could doubtless be made with some road having a somewhat uniform traffic to haul one of its trains, such as an express passenger train, consisting of say five or six cars daily, over its road on schedule time, with the engines to be tested. Each one would make one or two round trips with the train of normal size. Cars would then be added to it on successive trips, until the train reached the maximum weight which each engine could haul on schedule time. A half dozen trips would probably be sufficient for each engine, but if a storm or other serious disturbance to the working of the engine was encountered which was not its own fault the test for that day could be declared void and the trip would be repeated. The fuel consumed during each run would be carefully weighed, and an exact record kept of it, and the weight of the trains hauled each trip and the time of arrival and departure from stations. These would be about all the observations which would be essential to make, excepting perhaps to note the weather and the number of passengers carried. One trip should be made over the road on schedule time with the engine and tender alone, without any train, as the consumption of fuel under these conditions is sometimes very significant in indicating the inefficiency and defects of a locomotive.

If the committee should choose for trial only the best examples of locomotives adapted for the service selected, there would be little more risk of interference with the regular running of the trains on the line where the tests are made than there would be if the ordinary locomotives of the line were used. The rule should, however, be laid down by the committee that no locomotive belonging to the road on which the experiments are made should be tested there. In other words, no home locomotive should be allowed to compete with strangers on its own road. The reason for this is obvious, as favoritism would be certain to be shown to it by the members of the family at home.

Of course the above is only the merest outline and suggestion of the conditions which should govern such a trial. Doubtless a committee in conference would see directions in which such conditions would require extension and elaboration, but what is insisted on here is that the test should be a competitive one between different locomotives, all on a foreign road, to show practically which is best adapted and most efficient in a certain kind of traffic. More scientific investigation and analysis might be desirable later, to ascertain the causes of some of the phenomena revealed by the tests.

Suppose, now, that the committee should stipulate that only four-coupled locomotives should be tested in the first series of trials, and that the weight of those to be tested must not exceed 122,000 pounds, or be less than 118,000 pounds, in working order. Perhaps no other limitation would require to be made excepting perhaps that the weight on any pair of wheels must not exceed 41,000 pounds or less than 39,000 pounds. The builder should be permitted to make his engine of any form and proportions that he might choose, the only stipulation being that the combination of metal, wood, water and fuel must be within these limits of weight. The locomotives might be either compound or simple, and have two, three or four cylinders, single or double smokestacks, as the designer might prefer, the problem for solution being what combination of material of that weight will form the most efficient locomotive for the kind of traffic stipulated.

Supposing now that three approved simple locomotives of the American, one of the Columbia and one of the Atlantic type and one or two compound engines were selected for trial, and a record was kept of the performance of each. The work would be done on the same road, on the same schedule time, and as nearly as possible under like conditions, and no engine would be nursed by its friends, excepting so far as the skill of the men who run it could bring out its best performance. The comparison of such a record would be quite sure to indicate clearly which of the engines was the best for the service in which they were employed, and a knowledge of the results might be of incalculable advantage to the railroad companies of the country.

If the locomotives to be tested and the men to run them were furnished free of cost by their builders, and the railroad company on whose line the tests were made would supply the fuel, there would be but little expense in making such an investigation, excepting the pay and expenses of the persons in charge of them and perhaps some cost for labor and appliances in weighing coal. Some extra cars would have to be supplied to increase the train loads in some of the runs, but this would involve no outlay of money.

In view of the value of the knowlege which would be likely to be elicited by such experimentation it seems as though there ought not to be any difficulty in raising the comparatively small sum of money required to pay the cost of making such tests.

M. N. F.

THE BREAKING IN TWO OF FREIGHT TRAINS.

Since the topical discussion on this subject at the convention of the Master Car Builders' Association in 1897, a great deal of attention has been given to the part which the couplers play in these accidents, and the committee report last year, also treats of this side of the question. During the year it has developed that there are several influences besides those connected with couplers which need investigation and attention by the association.

Among the causes for the parting of trains the following may be mentioned: Defective designs of couplers, which permit the locks to work open on the road, due to the oscillation of the cars; defective uncoupling devices, which are too short in the connections and cause the locks to be lifted when the couplers are drawn out by heavy pulls; swaying of the train on account of variable braking power among the cars, due to defective adjustment of slack; surging in the train on account of sluggish triple valves that have not been inspected and cleaned often enough, and last and probably most important of all is the parting that is due to the methods of handling the brakes on trains that are only partially equipped with air brakes. Closely allied to the last cause is the matter of arrangement of the cars, in partially air braked trains, which should be such that the effects of the cars upon each other shall be as small as possible.

The brakes have much to do with break-in-twos. The equipment of cars with air brakes is progressing very rapidly, and it is believed that when trains are made up of all air braked cars, much of the trouble will stop, providing the necessary improvements in couplers and their unlocking devices are made. The best solution of the partially equipped train, therefore, is to equip all cars as rapidly as possible. In the meantime, how to handle partially equipped trains, and how to arrange the air braked cars in trains, are questions upon which there are wide differences of opinion.

The question of how to handle the slack between the cars has been given special prominence by a paper by Mr. C. L. Nichols of the Chicago, Rock Island & Pacific, read last August before the Central Association of Railroad Officers. (See Railroad Gazette, Oct. 22, 1897, page 739.) Briefly stated the use of a few hand brakes at the rear of the train is advocated, the air braked cars being placed next to the engine, and Mr. Nichols' rules require the trainmen, at every stop, to treat the train as if it were broken in two. The rear brakes are used to stretch out the slack before the application of the air brakes by the engineman. Figures from the records of the road appear to support the plan, but it is so entirely contrary to what many good authorities recommend as to warrant skepticism, and one authority goes so far as to say that he does not believe the Rock Island men obey the rules.

While the profile of the road has much to do with the use of the brakes the bunching of the train by light application of the air brake by the engineman has the indorsement of best practice, and it will require the strongest of reasons to induce general use of any other method. If hand brakes are to be used in the bunching of the train, they would probably be most effective if applied at the head of the non air brake cars. The air brakes may then be operated in harmony with the hand brakes better than those at the rear of the train. The proportion of air braked cars is now generally about one-third of the number in each train, which is enough to control the train as far as retarding power is concerned, and the use of the hand brakes, if they are to be used at all, should be to assist the engineman in avoiding the parting of the train. The best authorities on the air brake advise the shutting off of the engine far enough back to permit the slack to "run in" as far as possible, this to be followed by the application of the minimum amount of air that will insure driving the pistons past the leakage grooves, and after this such further reductions as may be necessary, making, however, but one application of the air brakes, and avoiding the release of the brakes on a long train until the train has stopped. Particular stress is laid upon the fact that the slower the train is moving the more likely it is to part, and this is supported by the figures given in the committee report at the 1897 Master Car Builders' convention. It is a good plan to hold the train "by the tail" after it has broken in two, but brakes at the rear may be expected to cause them to break.

It is customary to place the air brake cars at the head end of the train, and loaded cars usually precede unloaded ones, while the non air brake cars are put at the rear. Mr. Edward Grafstrom presents a strong argument (see Engineering News, December 23, 1897, page 411) for placing the empty air brake cars next the engine, followed by loaded air brake cars, while the non air brake cars bring up the rear. He reasons that a non air brake car retarded only by the friction of the journals will produce more impact upon an empty air brake car than upon a loaded one, because the difference between the velocity of the non air brake car and the empty air brake car is greater than that between the non air brake car and the loaded air brake car. He believes that when empty air brake cars precede loaded ones, and these are followed by non air brake cars, the latter, when the brakes are applied, will gradually give up their energy to the loaded air brake cars successively, and at the same time the empty air brake cars in front have begun to take up the energy of the foremost loaded air brake cars, and that by the time the non air brake cars and the loaded air brake cars have been brought to the same velocity, the latter and the empty air brake cars have also been brought to the same velocity. On the other hand, when the usual arrangement of empty air brake cars between loaded air brake cars and unbraked ones obtains, when the brakes go on the loaded air brake cars will jerk the first empty air brake cars forward, while the next moment the unbraked cars will be brought up sharply against the rear of the empty air brake cars, which are then stretched out with slack between them. This argument is worthy of careful attention.

It is an easy question to settle by experiments upon different arrangements of the cars in the same train and the relative amounts of shock obtained might be recorded by "slideometers" placed at several points along the length of the train. It would cost so little we should think the association would find it profitable to investigate thoroughly. It seems probable that this arrangement of cars might work desirably in ordinary service application of the brakes, but it would surely be a good thing in making emergency stops. Summing up, we should say that:

Couplers should be made so that they will not open accidentally, triple valves should be cleaned at regular intervals, at least once a year; automatic brake slack adjusters should be applied as rapidly as possible, the best method of handling partially air braked trains, and the best arrangement of cars should be studied, but the best solution of all for this difficulty of trains parting is to put air brakes on every car at the earliest possible moment. They will tend to reduce break-in-twos and will reduce the dangers from those that they do not prevent.

A plan for rewarding conscientious efforts to do good work on the part of enginemen, firemen and brakemen in freight service has been adopted on the Cincinnati, New Orleans & Texas Pacific Railway, in the form of semi-annual premiums. The premium for enginemen is $40 and for firemen $20, for making schedule time, freedom from accidents, particular stress being laid upon accidents from break-in-twos, tidiness of the engine, and economy in fuel consumption, obedience of the rules and specially meritorious acts. The premium for brakemen is $20, and is based on clean accident record, specially regarding break-in-twos, tidiness of caboose, observance of rules, and specially meritorious acts. Any system providing prompt, material and unprejudiced reward for efforts to serve employers well must result favorably. The administration of a system of this kind requires the utmost skill and fairness. It is believed to be based on a correct principle in human nature, and the plan must commend itself to every one, but without the element of scrupulous justice it had better not be tried.

LOCOMOTIVE DESIGN—THE WORKING STRESS OF MATERIALS.

By Francis J. Cole.

Driving Axles.

It is safe to assume that the determination of the size of locomotive driving axles is governed in nine cases out of ten by the area of the bearing surfaces alone. For a given load to be borne on each journal, a certain number of square inches of bearing surface is provided and the pressure kept within such limits as experience has demonstrated to insure cool running and freedom from excessive wear. Some idea then of the limitations of the pressure it is advisable to use seems necessary. The maximum is in the neighborhood of 220 pounds per square inch, the net weight resting on the journals, exclusive of the driving wheels and axles, being considered as the load. The minimum is noted at 130 pounds. This does not mean the lowest ever built, but a lower limit, under which it does not seem advisable to go, in order to guard against excessive size and clumsiness. A pressure of 175 pounds is suggested as suitable for ordinary conditions. When axles and bearings of exceptional wearing quailties are used a somewhat higher pressure could perhaps be allowed, and for inferior materials a somewhat lower pressure might be advantageous, but for ordinary "every day" conditions the figure named would be found satisfactory.

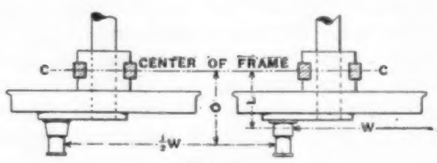


Fig. 1.

There is, however, another side of the question to be considered: it is possible to provide ample bearing surface and yet have an axle greatly overstrained. A journal 7 in. in dia. by 12 in. long has a bearing surface of 84 square inches, but its strength is much inferior to one 8 in. dia. by 10½ in. having a bearing surface of 85 square inches; the section modulus of the former would be 33.68 and the of the latter 50.27, while both have about the same capacity for wear. The distance from the center of the frame to center of the cylinder may be much greater in one case than the other, while the journal weight would remain the same. Yet the stress in the case of the greater distance would be increased directly as the distance. The stresses in driving axles are:

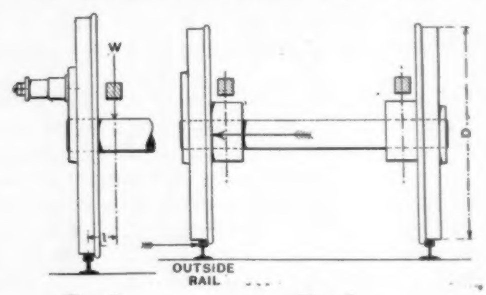


Fig. 3. Fig. 4.

(a) The bending stress caused by the piston thrust or pull transmitted through the main connecting rod to the crank pins, and resisted by the driving box held rigidly in the jaws of the engine frames. (b) The bending stress caused by the weight of the engine carried on the axle acting at right angles to (a). (c) The torsional stress caused by the unequal adhesion of the wheels. (d) The bending stress caused by the centrifugal force when rounding a curve resisted by the flanges of the wheels. The principal stress is that caused by the force of the piston, shown in Fig. 1.

The extreme fiber stress for a solid circular section fixed at one end with a single load at the other:

$$S = \frac{W\,L}{\left(\frac{\pi\, d^3}{32}\right)} \text{ reducing to } \frac{W\,L}{0.0982\, d^3}$$

In Fig. 1 an eight wheel engine of the American type is shown, having two pairs of coupled wheels and the main rod next the wheel hub, in which:

W=force of the piston.

L=center of main rod to center of frame.

O=center of parallel rod to center of frame.

C. C.=center of main frame.

M=bending moment.

R=section modulus for solid circular sections $= \frac{\pi\, d^3}{32}$ reducing to $0.0982\, d^3$.

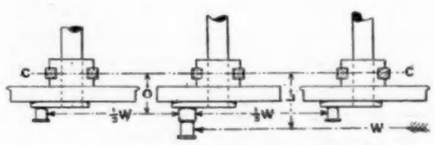


Fig. 2.

S=maximum fibre stress per square inch. Then for the main axle the bending stress per square inch will be:

$$S = \frac{\frac{1}{2}\, W\, L}{R}$$

For the back axle the bending stress per square inch will be:

$$S = \frac{\frac{1}{2}\, W\, O}{R}$$

Taking the following assumed values: Diameter of cylinder = 20 inches; pressure of steam = 180 pounds; L = 15 inches; O = 20 inches; diameter of axle, 8 inches; limit of wear 7½ inches.

Then for the main axle:

New axle 8 inches diameter $= S = \frac{.5 \times 56520 \times 15}{50.27} = 8430.$

Worn out axle 7½ in. diameter $= S = \frac{.5 \times 56520 \times 15}{41.34} = 10250.$

For the back axle:

New axle 8 in. diameter $S = \frac{.5 \times 56520 \times 20}{50.27} = 11240.$

Worn out axle 7½ in. diameter $S = \frac{.5 \times 56520 \times 20}{41.34} = 13.670.$

For a Mogul or 10 wheel engine, having the main connecting rod outside the parallel rod, the conditions will be as shown in Fig. 2. For the main axle the bending stress per square inch will be:

$$S = \frac{\frac{1}{3}\, W\, L}{R}$$

For the back and front axles the stress per square inch will be:

$$S = \frac{\frac{1}{3}\, W\, O}{R}$$

For a consolidation engine the bending stress per square inch for the main axle will be:

$$S = \frac{\frac{1}{4}\, W\, L}{R}$$

For the front, back and intermediate axles the bending stresses will be:

$$S = \frac{\frac{1}{4}\, W\, O}{R}$$

The decrease of the diameter of the axle, caused by the journal wear, must always be considered. The worn out size should be used as the basis for the calculation. If an axle is 8 in. in diameter when new, and the limit of wear is 7½ in., use

the latter diameter for figuring the effective strength, and not the primary size. The life of an axle should be limited only by the allowable journal wear, and not from any empirical rule, based on its mileage, provided, however, that it is originally of suitable proportion to keep the stresses within reasonable limits. Otherwise it might be necessary, when the axle was overstrained, to proceed on the assumption that it might break after a few million repetitions of the load, and remove it before a possible failure took place. The stress due to the dead load is caused by the weight resting on the driving box multiplied by the distance from the center of the engine frame (or, what is the same thing, the center of driving box) to the center of the rail, as in Fig. 3, in which:

W=load on each journal.

l=lever arm, center of box to center of rail in inches.

R=modulus of section of axle when worn out.

Then:

$$S = \frac{Wl}{R}$$

The torsional stress is caused by the turning moment of one crank when at or near half stroke, and consequently at its maximum force (the turning moment of the opposite crank being then at zero), exceeding the adhesion of its own wheel, or when, on slippery parts of the rail, a portion of the force is transmitted by the axle, to the opposite wheel. It is not probable that under any circumstances could more than half the turning moment be transmitted by the axle to the opposite side. Using the well known formula for torsional stress, in which

S=maximum shearing fibre stress per square inch.

W=force or weight.

L=lever arm.

R=modulus of section of axle when worn out.

$S = \frac{2\ W\ L}{\pi\ r^3}$. But in this case it is more convenient to use R the modulus of section instead of the expression $\pi\ r^3$ (the cube of the radius, multiplied by 3.1416) and making the proper substitution $S = \frac{\frac{1}{2}\ W\ L}{R}$

The stress due to centrifugal force is caused by the engine passing around a curve, the mass being diverted from moving in a straight line by the flanges of the wheels pressing against the outer rail. The well known formula for centrifugal force will enable us to determine the pressure against the rail, for any given weight, radius of curve and velocity; the resultant bending stress on the axle can then be easily calculated.

$$\text{Cent. } F = \frac{W\ v^2}{g\ r} \text{ in which:}$$

F=centrifugal force in pounds.

W=weight in pounds of the moving mass of one pair of wheels resting on the rails.

g=gravity 32.2 lbs.

r=radius of curve.

v=velocity in feet per second.

The centrifugal force for each pound of weight for a few different radii of curves and speeds in miles per hour are given:

$$10^\circ \text{ curve, speed 60 miles} = \frac{v^2}{r\ g} = \frac{7744}{573 \times 32.2} = .419 \text{ per lb.}$$

10° curve, speed 40 miles per hour=.186 per lb.

6° curve, speed 60 miles per hour=.251 per lb.

Probably the latter is the greatest flange pressure due to the centrifugal force for which provision need be made.

The bending stress at the axle will cause the upper fibres to be in tension and the lower in compression, or directly opposite to and partly or wholly neutralizing at times that due to the dead load, as in Fig. 4:

$$S = \frac{F\ W\ (\frac{1}{2}\ D)}{R} \text{ in which:}$$

F=centrifugal force.

D=diameter of wheel.

The foregoing is based on the supposition that the curves have no elevation of the outer rail, and that all the centrifugal force is resisted by the wheel flanges, but as all curves on the main track have some elevation of the outer rail it is manifest that a part of this force is absorbed by the inclination of the track and that something less than these figures must be taken. Theoretically, for a given radius and speed it is possible to give the proper inclination to the track suitable for these conditions with such a degree of refinement that there would be no flange pressure on the outer rail, but all would be resolved instead into a force acting perpendicularly to the rails. In practice, however, this cannot be done, the elevation being a compromise between fast and slow trains, so that at high speeds much of the centrifugal force is transformed into flange pressure. The proper theoretical elevation of the outer rail can be calculated by means of the following formula:

$$E = \frac{d\ v^2}{32.2\ r} \text{ in which:}$$

E=elevation required.

d=distance between center of rails.

v=velocity in feet per second.

r=radius of curve in feet.

It is evident that the sum of the various stresses will not be the actual maximum fibre stress at any one part of the axle, as they act in different planes and directions and must be combined in order to obtain the correct resultant at a given point. The crank pin pressure produces bending in the axle at right angles to that produced by the dead load, or by the centrifugal force producing pressure against the flanges.

Let C=bending stress from crank pin pressure.

Let D=bending stress from dead load.

Let S=resultant or combined stress. Then:

$$S = \sqrt{C^2 + D^2}$$

Graphically, the resultant is equal to the hypothenuse of a right angled triangle, in which the length of one side is equal to C and the other side to D, as in Fig. 5. To combine the re-

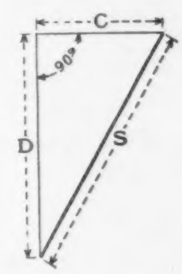


Fig. 5.

sultant stress obtained by the combination of the crank pin and the dead load stress with the torsional stress:

Let T=torsional stress.

Let S=combined bending stress.

Let Y=resultant.

$$\text{Then } Y = \frac{S}{2} + \sqrt{\frac{S^2}{4} + T^2}$$

Probably one-half the torsional stress is all which should be used. The calculations in detail of a mogul locomotive is given below:

Cylinders, 19x26 in. Steam pressure, 180 pounds per square inch. Diameter of axle, 8 in., minimum size assumed to be 7½ in. Diameter of driving wheel, 56 in.

L=19½". See Fig. 2.

O=14". See Fig. 2.

W=50940.

R=section modulus.

Bending moment for main axle (when worn to 7½ in.) due to force of piston:

$$S = \frac{\frac{1}{3}\,W\,l}{R} = 8010.$$

Bending moment for main axle due to dead load:
W=14500.
Z=6″.

$$S = \frac{W\,l}{R} = 2100.$$

For the torsional stress, the force of the piston is divided equally between the driving axles (in this instance there are three axles); therefore:

$$S = \frac{16\,W\,l}{\pi\,d^2\,3} \text{ or } \frac{2\,W\,l}{\pi\,r^3\,3} \text{ or } \frac{\frac{1}{2}\,W\,l}{R\,3}$$

and using the latter

$$M = \frac{\frac{1}{2}\,W\,l}{3} = \frac{25470 \times 13}{3} = 110370$$

$$S = \frac{M}{R} = \frac{110376}{41.34} = 2670 \text{ pounds.}$$

Assuming that one-half of this is the maximum torsional stress likely to occur at any time we have $\frac{2670}{2} = 1335$ pounds.

For the bending moment due to centrifugal force, the weight resting on the rail of one pair of drivers=36500. Curve 6°= 955 feet radius. Speed 50 miles per hour=73.3 feet per second.

$$\text{Cent. } F = \frac{W\,v^2}{g\,r} = \frac{36500 \times 5373}{32.2 \times 955} = 6370. \quad \text{Lever arm} = \tfrac{1}{2}$$

diameter of driving wheel $\frac{56}{2} = 28$.

$$S = \frac{F\,(\frac{1}{2}\,D)}{R} = \frac{6370 \times 28}{41.34} = 4310 \text{ pounds.}$$

Probably the flange pressure would not exceed one-half of the total centrifugal force, the remainder being absorbed by the elevation of the outer rail $\frac{4310}{2} = 2155$ pounds, or very slightly in excess (55 lbs.) of the dead load which it neutral-

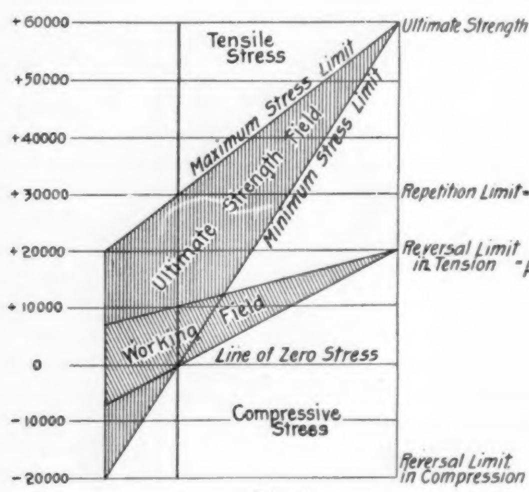


Fig. 6.

izes. Where the diameter of the wheel is so large that the stress due to the centrifugal force is much greater than that due to the dead load stress, it should be used in its place.

Combining the crank pin and the dead load stresses:

$$S = \sqrt{C^2 + D^2} = \sqrt{8010^2 + 2100^2} = 8280.$$

Combining the above resultant with the torsional stress, taking the latter at one-half

$$Y = \frac{S}{2} + \sqrt{\frac{S^2}{4} + T^2} = \frac{8280}{2} + \sqrt{\frac{8280^2}{4} + 1335^2} = 8490$$

pounds maximum fibre stress when the main axle is worn down to 7½ inches diameter.

Actual breakages of driving axles confirm the statement that the main axles on freight engines, (main rod outside the parallel rods) and the back axles on passenger engines, (main rod inside), are subjected to much higher stresses than the other axles. The majority of breakages will be found to occur in the axles named, when the diameters are the same for all the driving axles under the same engine. For freight engines the main axle is sometimes made larger in diameter than the others. If it is desirable to make the engine as light as possible this is a good plan, otherwise it is better to make them all alike, basing the size on the requirements of the main axles. The following table gives the maximum stresses (figured on the diameter when worn out) which are suggested for different types of engines:

	Ham. Iron.	Steel.
Consolidation	7,500	8,500
Ten-wheel and mogul	8,500	9,500
Passenger 8-wheel	10,500	13,000

The steel is assumed to be first-class open hearth steel of not less than 80,000 lbs. tensile strength, with an elongation of not less than 18 per cent. in two inches, and phosphorus not above 0.05.

Modulus of Solid Circular Sections.

$$R = \frac{\pi\,d^3}{32} = .0982\,d^3.$$

Dia.	M. of S.	Dia.	M. of S.	Dia.	M. of S.	Dia.	M. of S.	Dia.	M. of S.
1	.098	3	2.65	5	12.27	7	33.68	9	71.58
1⅛	.139	3⅛	2.99	5⅛	13.27	7⅛	35.52	9⅛	74.52
1¼	.191	3¼	3.37	5¼	14.21	7¼	37.31	9¼	77.71
1⅜	.255	3⅜	3.77	5⅜	15.25	7⅜	39.38	9⅜	80.90
1½	.331	3½	4.20	5½	16.33	7½	41.34	9½	84.18
1⅝	.421	3⅝	4.67	5⅝	17.47	7⅝	43.53	9⅝	87.55
1¾	.526	3¾	5.18	5¾	18.66	7¾	45.71	9¾	90.91
1⅞	.647	3⅞	5.71	5⅞	19.90	7⅞	47.95	9⅞	94.55
2	.785	4	6.28	6	21.21	8	50.27	10	98.20
2⅛	.942	4⅛	6.89	6⅛	22.56	8⅛	52.70	10⅛	101.9
2¼	1.12	4¼	7.53	6¼	23.96	8¼	55.14	10¼	105.7
2⅜	1.31	4⅜	8.22	6⅜	25.43	8⅜	57.68	10⅜	109.6
2½	1.53	4½	8.94	6½	26.96	8½	60.30	10½	113.6
2⅝	1.77	4⅝	9.71	6⅝	28.55	8⅝	63.00	10⅝	117.8
2¾	2.04	4¾	10.53	6¾	30.00	8¾	65.78	10¾	122.0
2⅞	2.33	4⅞	11.37	6⅞	31.91	8⅞	68.64	10⅞	126.3

Driving axles almost invariably break close up against the inside of the wheel hub and not in the center of the journals, where the figured maximum bending stress occurs, assuming an axle of uniform diameter. This is due to three causes: (a) The concentration of the bendings and vibrations at the rigid wheel center. (b) The common practice of reducing the diameter of the wheel fit ⅛ to ¼ inch below the size of the journal. (c) The loss of strength caused by cutting the keyway in the wheel fit on the side next to the crank pin. This reduces the strength on the side which is subjected to the greatest stress.

In a general way it seems to be a fact that as the number of pairs of driving wheels increase, the stress should be decreased. This seems plausible, too, when it is remembered that any variation in the adhesion of the drivers increases the stress on some of the axles, the force not being equally divided; also, that the adjustment of the parallel rods may be such, that the thrust of the main rod is not evenly distributed between all the wheels, the main pair having to withstand the excess up to its limit of adhesion, on possibly at times, a well sanded rail. On freight engines the range of stress is greater than on passenger engines, as the steam pressure is not so much reduced towards the end of the stroke, the point of cut off being usually much longer in freight service. The initial pressure in the cylinders at the commencement of the stroke approaches at times nearly to boiler pressure and is prolonged or reduced according to the speed and point of cut off, so that the full force is applied to the pin at the beginning of the stroke in one direction and at the end of the stroke, or nearly at the end, when the pin has turned over (presenting its other side), part of the force is applied in the opposite direction. The stress is, therefore, alternating, the pressure at the ter-

mination of the stroke being the minus amount, or the reversal load below the zero line.

The relations existing between the three general methods of loading are summed up by a well known authority as follows: Unwin reasons from the result of Wohler's experiments, "that a real factor of safety can be used between the working and the breaking stress. For ductile iron and steel the ultimate strength, or the stress at which fractures will take place, when repeated an infinite number of times is:

Static or dead load=the ultimate strength=1.00.

Load applied and entirely removed=.6 ultimate strength =.60.

$$\text{Alternating load} = \frac{\text{ultimate strength}}{3} = .33.$$

"These figures can be taken as actually representing the ultimate strength of the material under three general methods of loading. The working stress should be based on these calculations."

J. B. Johnson in "Materials of Construction" shows graphically the working field for the different methods and degrees of loading, summing up all the reliable data on hand regarding the fatigue of metals from the experiments of Wohler, Bauschinger, U. S. Arsenal at Watertown, as in Fig. 6:

Static load limit=S=ultimate strength.

Repetition limit=p_1=½ ultimate strength.

Reversal limit=p_2=⅓ ultimate strength.

When the ultimate limits are reduced to working limits p_1 is supposed to reduce to a then:

Working static-load stress=2a.

Working live-load stress=a.

Working reversed stress=⅔a

Let p=maximum stress in the member per square inch for both dead and live loads.

Let a=working stress for live loads.

$$p = \frac{a}{1 - \dfrac{\text{minimum stress}}{2\ \text{maximum stress}}}$$

The necessity for a lower stress, when an alternating load is to be resisted, is therefore apparent. The writer is firmly of the opinion that nearly all the failures of steel axles, when of suitable proportions, have been caused by the use of improper grades of steel. Because Bessemer steel is a suitable material for rails, it does not necessarily follow that it is desirable for axles, and superior and more durable than hammered iron. Nor does it follow that soft or mild steel, of say 55,000 to 65,000 lbs. tensile strength, which is so reliable and tough (its use being so satisfactory for boilers, plates, shapes, etc.), should prove a suitable material when good bearing surfaces and freedom from breakage are required. Mild steel for some years has been regarded by many very much in the light of a patent medicine which could be used for all purposes and guaranteed to be a universal panacea. It may seem unnecessary to some who have outgrown this belief, to again call attention to the fact that mild steel is not a suitable material for axles. It is advisable to specify exactly what is wanted when material for this purpose is required, and to test it afterwards to see whether the conditions have been complied with, or to purchase of some reliable dealer, whose reputation and price are at once a guarantee of its quality and suitability for the purpose. Steel of a high tensile strength and elastic limit, with enough elongation to insure its toughness and ductility, made by the open hearth process, of say 80,000 to 90,000 lbs. tensile strength, with an elongation of 22 per cent. in 2 inches, and phosphorus not over 0.05 per cent., when thoroughly worked and well hammered, is an entirely reliable material and superior in every respect to wrought iron or mild steel. It is a matter of observation that its use is becoming more general every day. This grade of steel is still further improved by various methods of tempering or annealing, in which the forging strains are neutralized and by the addition of nickel in small quantities. The conclusions are:

That driving axles should be first designed to afford sufficient bearing surface to insure cool running, the proportion being about 1 square inch to 175 lbs. of net load, and secondly, for the known forces which give rise to stresses in the metal, keeping the fiber stress within safe limits.

By far the greatest bending stress is due to the direct thrust of the piston, the stresses from other causes being comparatively insignificant in comparison.

The greatest stress is on the main axle in freight engines and on the back axle in passenger engines.

When it is advisable to reduce the bending moment, the spread of the cylinders should be made as small, and that of the engine frames as great as practicable.

That hard steel having a high elastic limit and suitable ductility, possesses the properties of being a good bearing material and capable of resisting severe shocks, is well adapted for axles.

WINANS' CAMEL ENGINES.

By M. N. Forney.

The Baltimore & Ohio Railroad, as most readers know, was one of the pioneer railroads in this country, and its shops in Baltimore were commenced away back in the early thirties, and ever since have been located at Mount Clare, and some of us old fellows can remember queer things, which could be seen here away back in the fifties. Until within a few years ago there were still some of the old grass-hopper engines, with vertical boilers and vertical cylinders, at work about these shops, switching cars on the crooked tracks and sharp curves, of which there were then and are still so many at Mount Clare. Some of these locomotives were in continuous service for over fifty years, a record which probably cannot be equalled by any other locomotives in the world. They have now all gone into the scrap-pile, excepting the one preserved in the Field Columbian Museum in Chicago.

Another type of locomotives used more extensively, and retained longer in the Baltimore & Ohio Railroad than on any other line, were the Winans' camel engines. Only three specimens of these remain. Two of them, battered and worn, and much altered from their original design, were standing on a side track at the time the observations here recorded were made, and the fiat had gone forth that they should be cut up and destroyed. There is but one more on the road, and that, too, will doubtless soon follow its predecessors, and then this type of locomotive will be as extinct as the dodo. It is very much to be regretted that no complete drawings of these engines are now in existence, and owing to the alterations which have been made in them it would be impossible to reproduce them accurately now. Very soon even the recollection of them, which still remains in the minds of some of us who are left, will also be gone, and the future writer of the history of the locomotive, like some of his predecessors, will be obliged to do a great deal of guessing.

Some description of these locomotives may now be interesting to the younger readers of the American Engineer. The outline engraving of the camel engine, Fig. 1, which is given herewith, has been made from an old lithograph which was issued in 1852, as an advertisement by Ross Winans, who was the designer and builder of these engines. Many of the minor details were omitted in this lithograph, but all that is shown on it is approximately correct. The title on it is

TRANSPORTATION ENGINE,

ADAPTED FOR THE BURNING OF ANTHRACITE OR BITUMINOUS COAL.

MANUFACTURED BY

ROSS WINANS,

BALTIMORE, MD.

The following "remarks" are inscribed on one corner of the lithograph:

Weight of engine with coal and water	24	tons.
Diameter of boiler	46	inches.
103 tubes, 2½ inches outside diameter	14 feet 1¼	inches long.
Fire surface in tubes	903	square feet.
" " " firebox	86½	" "
Area of grate	24½	" "
Diameter of wheels	43	inches.
" " cylinder	19	"
Length of stroke	22	"
Works steam at full or half stroke.		

The other illustration, Fig. 2, is a wood engraving made from a photograph by Mr. R. McMurray, now chief inspector in New York for the Hartford Steam Boiler Insurance Company, and represents one of the Winans engines, which was rebuilt at the Mount Clare shops in 1864. A comparison of the two illustrations will show that some alterations were made in the process of rebuilding, which will be referred to later on.

Winans' shops were located in Baltimore, east of and adjoining the Mount Clare shops of the Baltimore & Ohio Railroad, and the writer was an apprentice there from 1852 to

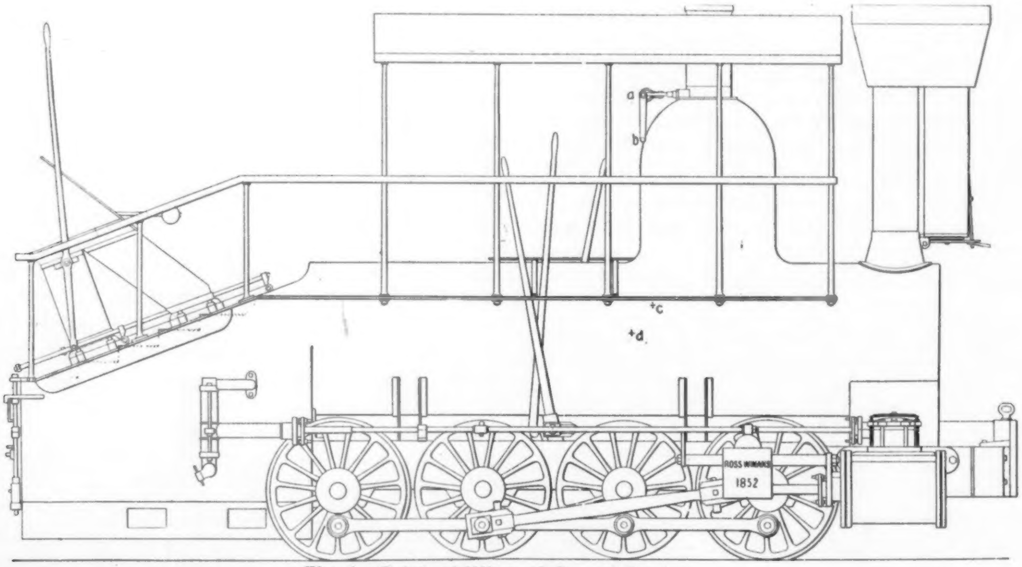


Fig. 1.—Original Winans' Camel Engine.

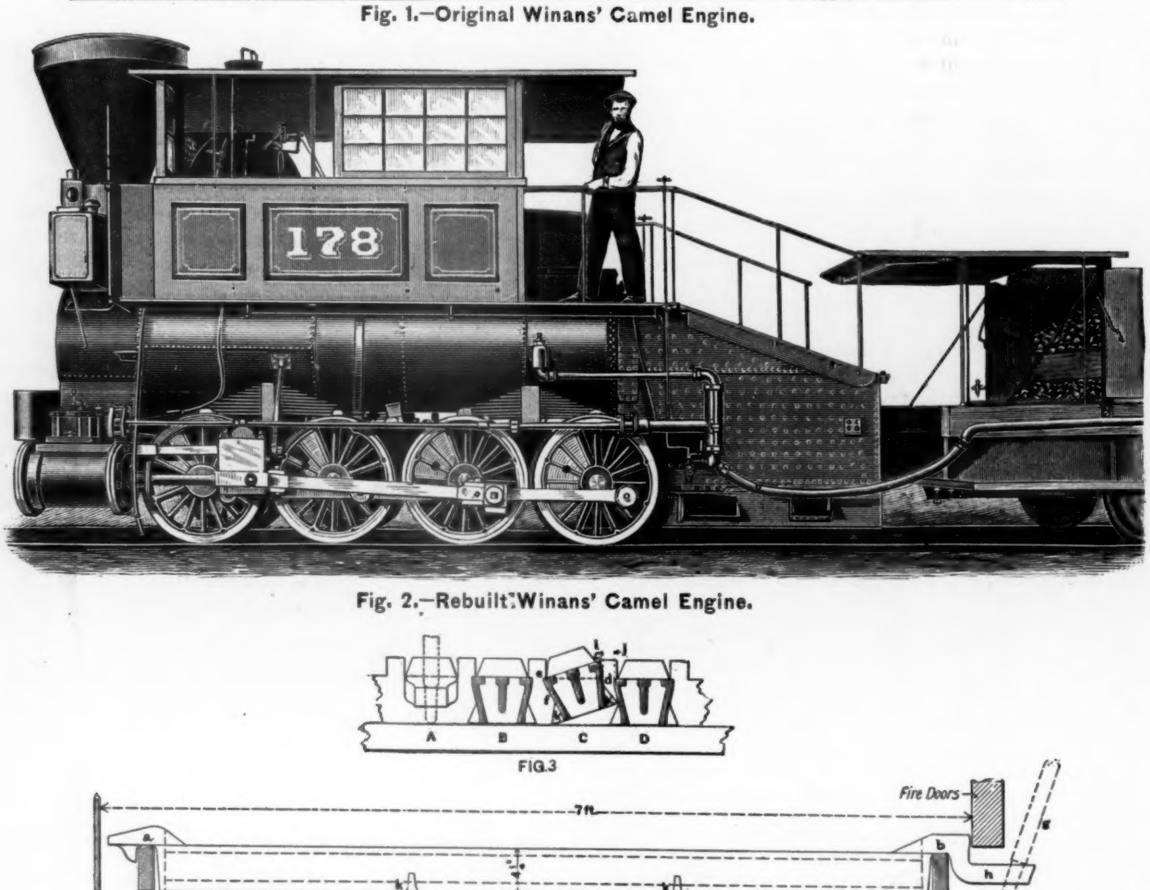


Fig. 2.—Rebuilt Winans' Camel Engine.

FIG.3

FIG.4.

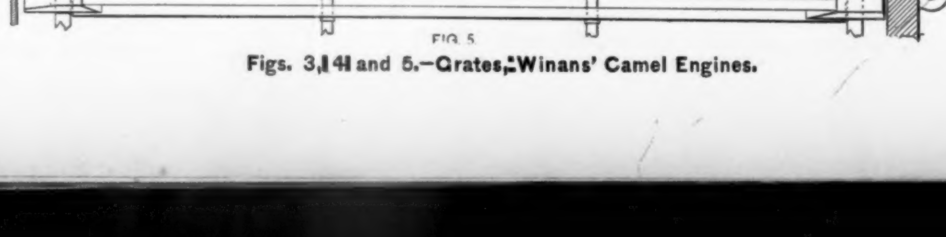


FIG. 5

Figs. 3, 4 and 5.—Grates, Winans' Camel Engines.

1856, and worked on the engines, and was therefore very familiar with the locomotive here described.

Just how the term "Camel" engines originated is not definitely known. It has been said that a man named Campbell, who designed the first "American" type of locomotive, with four coupled wheels, and a four wheeled truck, which was built in Philadelphia, had something to do with the construction of the first Winans engine of the "Camel" type, and that the term was a modified form of Campbell's name. Another version is that the large dome and cab on top of the boiler gave the engine a humped appearance analogous to that of a camel's back. A third is that the term was used in derision of the builder, who was very stooped and round shouldered, so as to appear almost deformed. Probably the second is the true origin of the term.

In the light of nearly fifty years experience, the merits and demerits of these locomotives may be recognized more distinctly than they were at the time they were built and in use, when they were the subject of much acrimonious discussion and bitter controversy. As will be seen from the illustration, the whole weight of the engine was on the eight driving-wheels, which had a wheel-base of about 11 feet 2½ inches, only a little more than some six-wheel trucks now used under sleeping cars. Consequently these locomotives would pass around curves and into sidings of such short radii, that an ordinary eight-wheeled American engine could not run over without danger of derailment. Having all their weight on the driving-wheels, they had great adhesion, and the small wheels combined with relatively large cylinders gave them great tractive power. The camel engines were therefore noted in their day for pulling heavy trains. Whether the weight given—24 tons—was intended to mean tons of 2,000 or 2,240 pounds, it is not now possible to know, but from the fact that the weight of locomotives is generally greater than it is reported, it is probable that there engines weighed nearer 63,760 pounds,or 24 long tons, than 48,000 pounds, or 24 short tons. They therefore had only 6,720 pounds on each wheel. As the standard rail of those days was made of iron, and weighed only 56 pounds per yard, the importance of having a light weight on each wheel is apparent.

The feature which will first strike a person not familiar with the design of these machines is the form of the fire-box. The top of this sloped downward from the back end of the cylindrical part of the boiler. The outside shell and the crown-sheet were both flat, and stayed with stay-bolts in the usual way. There was nothing especially novel in this form of construction even at this early day, as Stephenson's original "Rocket" had a fire-box, the top of which was depressed below the top of the cylindrical part. In some of the illustrations now extant, it is represented as sloping for only a part of its length, while in others it is shown sloping its whole length. At present the origin of this form of construction is not a matter of much importance, but its utility is. This kind of fire-box was employed quite extensively on the Reading Railroad, by Mr. Millholland, and was later adopted on the Pennsylvania road, on what are known as the old "Class I" locomotives, which are now designated as "H 1" under the new system of classification. The grates of the engine represented in the engraving were about 7 feet long, a very great length in their day. The fire-box was made the full width that was available between the back pair of driving-wheels. The boiler consequently had a very large grate area—equal to nearly 2½ per cent. of the total heating surface—and a large amount of coal could consequently be burned. The camel engines, therefore, had the reputation of being very free steamers. It will be seen that these locomotives had the three essential elements required to pull heavy trains. 1st, plenty of adhesion; 2d, large tractive power, and 3d, ample steam generating capacity. These features were of very great importance in the heavy grades of the Baltimore & Ohio and other railroads, and accounts for the extensive adoption of this form of locomotive in its day, and due credit should now be given to Winans for the combination of these elements in his engines.

As will be seen from the illustrations, the long fire-box overhung the back axle, and its weight had to be balanced by that of the cylinders, smoke-box and chimney, which overhung the front axle. In order that they should balance each other it was essential that the fire-box should be as light as possible, and doubtless it was for this reason that the sloping top was adopted, and that the dome was placed at the front end, and the engineer's cab on top of the boiler. The fireman's foot-board was on the tender, as shown in the wood engraving, and was very low down. In those days it was considered essential to keep the boiler as low as possible. The center of that of the engine here described was only about 67 inches above the top of the rail. That of the celebrated 999, on the New York Central Railroad, is 107½ inches, which shows the difference in this respect in the practice in the fifties and at the present time.

With the experience of half a century to guide us, much can now be said in favor of this form of fire-box. The boiler shop of the Pennsylvania Railroad, at Altoona, was formerly under the charge of a very intelligent foreman, Mr. Nixon. A few years ago the writer made especial effort to ascertain, in the light of past experience, what were the advantages and disadvantages of this form of fire-box. In consultation with Mr. Nixon he said unhesitatingly, that what was then known as the "class I" fire-box, which was similar to the camel form, was the cheapest one to build and to maintain, and also the lightest of any in use on the road. If these claims rest upon a sound basis of fact, and are sustained by experience, they are very strong arguments in favor of this form of construction. To ascertain the objection, if any existed, to the use of this form of boiler, some of the men who had run such engines, the round-house foreman and others were consulted. It was said by some of them on the Pennsylvania road that the class I boilers were rather poor steamers, and did not carry water very well.

On the Baltimore & Ohio, and also on the Pennsylvania road, there are still a number of men who ran camel engines when they were in use. Their general testimony was that the "old camels" were free steamers, and there was no difficulty in carrying water in them. It is, of course, true that in this form of boiler there is less steam-room than in one which has more or less steam space over the crown-sheet. This deficiency was compensated for in Winans' boiler by the large dome, which was placed near the front end. This, as will be seen from the engravings, was very large—almost 40 inches diameter—and 48 inches high. The poor steaming capacity of the class I boilers may be attributed to a deficiency in heating surface, and their disposition to "work water" to a lack of steam-room. The camel boilers had neither of these defects.

If then it can be said that this form of fire-box weighs less, costs less and is cheaper to maintain, generates steam freely, and carries water well, it is very strong evidence in its favor. The general principle has been enunciated and is undoubtedly a sound one, that within the limits of weight and space to which we are necessarily confined, a locomotive boiler can not be made too large. If now we were called upon to design a locomotive of almost any class to weigh, say, 100,000 pounds, if this form of fire-box was adopted it would be possible to increase the heating surface some hundreds of square feet and give the boiler greater water capacity than would be possible if the old-fashioned crown bars, radial-stays, or the Belpain form of fire-box was adopted. The inquiry may then be fairly put, whether a locomotive with a fire-box, the construction of which conforms to the predilections of its designer, but with materially less heating surface than another of the "camel" form, would do as much work as the latter in active service?

Another interesting feature in the fire-boxes of these old engines was the coal chutes on top, which are shown in Fig. 1.

When grates as long as 7 feet were adopted, it was supposed that it would be impossible to distribute the coal properly over so great an area. Winans, therefore, supplied his boilers with a pair of chutes on pipes, which were square in section, and of the form of an inverted letter V, which were attached to the top of the sloping fire-box as shown. There was an opening at the base of each of these, similar to furnace doors, and communicating with the fire-box, and closed with sliding doors over them, which were operated by a long lever, also distinctly shown. The top of the chute was closed with a hinged door, having a counter-weight, as shown in Fig. 2, so adjusted that it would hold the door either open or shut in whichever position the door was placed. The foot-board of the tender, from which the boiler was fired from the back end, was placed very low down—about on a level with the bottom of the fire-box. Over this was another platform high enough above the lower one so that the fireman could work below it, but it was in such a position that he could, without much difficulty, shovel coal from the tender to the top landing, as it might be called. From Fig. 2 it will be seen that the coal chutes were removed when the engine was rebuilt. The platform over the fireman's footboard was also removed. The covering shown is only a roof or awning, to protect him from rain and sun. Winans' plan for firing contemplated that the coal should be shoveled to the top platform, and the lower sliding doors of the chute being closed and the top one opened, the chutes were filled with coal. The top door was then closed and the lower ones were opened, which would thus allow the coal to fall on the fire, without opening direct communication with the outside air. Winans' plan looked very well in theory, but in practice the use of the chute was soon abandoned, and when the engines were rebuilt the chutes were taken off. Another peculiarity of many of the fire-boxes which Winans made, was that the whole back end was left open and the aperture was closed by a system of fire-doors. The hinges and some of their fixtures are shown in Fig. 1.

The grates were also peculiar and are illustrated by Figs. 3-5. Fig. 4 is a side view of one of the bars, which were 7 feet long. They were supported by two cast-iron bearing-bars, E and F, and rested on two intermediate wrought-iron bars, G and H, placed underneath, between the two ends. The form of the bars is shown by the sectional view, Fig. 3. From Fig. 4 it will be seen that they had necks, a and b, at each end, which rested on the bearing-bars. The under sides of these necks were on the same horizontal plane as the tops of the bars. An extension, h, on each bar projected below the fire-doors to the outside of the fire-box. Each of the extensions had a hole in it—shown in the plan, Fig. 5—to receive a shaking-bar, g, part of which is represented by dotted lines. Each of the grate bars could thus be shaken independently of the others, as shown by the bar, C, in Fig. 3, which is tilted on the corner, e, of the under side of the neck. The bar could be similarly rocked on the other corner, c. The outer edges of the bars, as c d and e f of C, are described from the corners, c and e, as centers. That is, c d is described from e as a center, and e f is described from c. The effect of this was that when the bars were tilted or shaken the spaces between them, as i j, were not increased or diminished, so that lumps of coal were not liable to fall between the bars when they were rocked and thus clog them. As each bar could be shaken separately from the others, there was less liability of the whole grate being clogged than there is when all the bars are connected and shaken together. To shake the different bars, as has been explained, a bar, g, was inserted in the holes in the ends of the extensions.

The grate was a marvel of cheapness. There was not a bit of machine work on any part of it, excepting that required to drill a few bolt holes in the outer ends of the bearing-bars, and if one of the grate bars was burnt or became distorted and had to be replaced it was simply lifted out and a new one put into its place without disturbing any other part of the grate. Between the two ends of the bars they were provided with projections, k k, which rested on the bearing-bars G and H, on which they rolled when the grate-bars were rocked. Altogether it seems to be the simplest form of shaking grate that has ever been used.

From the first engraving it might be supposed that a double smoke-stack or chimney, such as has been illustrated recently, was provided on these engines. Such was not the case, however. The front vertical pipe, which is shown in Fig. 1, was intended to serve the purpose of a receptacle for sparks and, as will be seen, had a door at the bottom for removing them. The top of the stack was rectangular in form and had for a spark arrester iron slats placed close together and standing up edgewise, instead of wire netting.

The smoke-box was provided with a variable exhaust, which consisted of a cast-iron box of the form of a frustum of a square pyramid, with a vertical division in the middle and open top and bottom. The exhaust-pipes were connected with the bottom openings. Into each of the two spaces in which the pyramidal box was divided, a loose vertical wedge shaped cast-iron partition was fitted, which could be moved horizontally. They were attached to horizontal shafts which were operated by two spiral cams or "worms" on a horizontal shaft which was connected with the cab by another shaft, and the two were connected together by a pair of bevel gears. In practice the movable partition referred to soon became immovable by the action of grease and cinders, and they were usually placed in their most effective position and left there.

The throttle lever was also different from anything which is used now. It consisted of a horizontal shaft, the end of which is shown at a in Fig. 1. This had an eccentric in it which is also shown and was connected by a rod and strap to the throttle stem. The shaft a had two levers, a b, attached to its ends, with horizontal handles extending outward from the levers in their lower ends. An end view of one of them is shown at h. To open the throttle valve these handles were raised upward and moved in an arc of a circle described from the center of the shaft a. Any jar had a tendency to cause the handles and levers to fall, and thus close the valve. The gage cocks were below the engineer's foot-board, about in the position indicated by c d, and the engineer was obliged to judge of the height of the water by the sound of the escaping steam and water alone. This was before the days of glass water gages. The safety-valves were held down by long levers which had spring balances on the ends.

The wheels with which Winans equipped these engines were solid cast-iron with chilled treads and without separate tires. His assumption being that it was as easy to take a wheel off of an axle and put a new one on as it was to renew a tire. On the Baltimore & Ohio and other roads the engines were, however, speedily equipped with wheels having removable chilled cast-iron tires. These were fitted to the wheels with a tapered seat and were held on with hook-headed bolts let into recesses cast in the wheel centers, the hooked head taking hold of the tire on the outside, and the nut had a bearing on the wheel center inside. An illustration of this method of fastening tires is given on p. 287 of the first edition of the Catechism of the Locomotive.

Winans was among the first, although not the first, engineer in this country to use solid-end coupling rods. He was roundly abused for it in his time, but the general practice of to-day conforms to what he advocated and practiced half a century ago.

The frames of his engines, as indicated in the illustration, were of the plate form and each frame consisted of two wrought-iron plates ⅝ inch thick. These were placed about 5 inches apart and were held together by bolts which had thimbles between the plates. The jaws were faced with cast-iron shoes; the main driving-boxes alone had wedges on one side only. The lower part of the smoke-box was square in form and made of sheet-iron about ¼ inch thick. The frames

and cylinder fastenings were, however, very weak and were constantly giving trouble.

The springs were originally placed between the plates which formed each of the frames and rested directly on the top of the driving-boxes. One-quarter inch bolts, which passed through the two frame plates, acted as a fulcrum for the springs. On the Baltimore & Ohio Railroad the springs were placed above the frames, as shown in Fig. 2.

The valve-gear would be a curiosity if a drawing of it could be reproduced to-day. The rockers were made of cast-iron—the end of the upper arm of one of which is shown in the engravings. It was long and of the form of an inverted letter L, and extended from the inside of the frame over its top and far enough outward so that the valve-stem could be connected to a pin in the upper and outer end, which was cast with the rocker. There were two eccentrics on each side—one for the forward full stroke and one for the back motion. A cam was provided on each side, which cut off steam at half stroke in the forward motion. There was no variable cut-off of any kind. The eccentrics and cams were connected to the rocker by old-fashioned hooks, which were lifted into and out of connection with the rocker by a series of other cams on a shaft under the hooks. This shaft was operated by one of the long levers shown in the engraving. The other one is a starting-bar for moving the rocker when the hooks were not in a position to fall into gear.

The pumps, it will be seen, were located on the sides of the fire-box and were worked by a long rod connected to the cross-head. The valve-stems were on the same horizontal plane as the pump-rods, and in Fig. 1 they appear like an extension of the latter. The connection of the pump-rods to the cross-heads gave trouble by breaking the cross-heads and piston-rods, and in some of the later engines the pump-rods were connected to curved arms fastened to the connecting-rods. The feed water, it will be seen, was delivered directly into the side of the fire-box, a practice which would not be approved now, and was condemned then. As shown by Fig. 2, the check-valve was placed forward and attached to the barrel of the boiler when this engine was rebuilt. This was the usual practice and a plate was often riveted to the inside of the boiler shell, to conduct the water from its point of delivery from the check-valve to the front part of the boiler. The rivets shown on the side of the boiler indicate that such a plate was used in the engine shown in the engraving.

The boilers were made of iron less than 5-16 inch thick, the seams being all single riveted. The plates of the shell at the base of the dome were curved in the form indicated in Fig. 1. The large opening where they were connected together was not strengthened in any way, excepting by some cross-braces at the base, which were attached to single bars of angle-iron riveted to the sides of the barrel of the boiler. The braces were simply flat bars with a ¾-inch hole drilled in them and another in the angle-iron. The bars were laid on top of the angle and bolted to it. The whole arrangement was pitifully weak and resulted in frequent explosions and dire calamity to the poor fellows who ran the engines and were on top of the boiler.

Owing to the great length of the tubes—14 feet 1¼ inches—it was found necessary to support them between their ends. A plate was therefore placed about midway between the tube-sheets, with a space between it and the shell of the boiler to permit the water to circulate. The holes in this plate were drilled large enough to allow the tubes to be passed through them without difficutly.

The draw-bars of these engines were different from any which were ever used before or since. They were of the form of a large letter V and were placed under the ash-pan, and riveted to it, the two upper arms of the V being bent upward and were bolted to one of the plates of each frame immediately in front of the back driving axle. The apex of the V extended behind the fire-box and had an eye to receive a coupling-pin. Another heavy single bar was connected to a large casting, on the tender, between its two trucks, and to the eye of the V-shaped bar. This wretched connection was the only appliance for resisting concussion between the engine and tender. The fireman was down in a position in which he could not see danger ahead, and at some distance from the engineer, so that he could not easily get warning from him. The side timbers of the tender, which are shown in Fig. 2, were so far apart that in case of collision they would allow the fire-box to be driven in between them, and the poor fellow who was at work there was almost certain to be crushed to death, and if not, the horror of being burned and scalded were added. The number who met this fate in these wretched man traps will never be known, but the awful danger of the whole contrivance makes one shudder even at this late date.

From the description it will be seen that the draw-bars were placed very low down and close to the top of the rails. This led to an animated controversy, in which the brilliant but erratic Zera Colburn took a part, about the effect of this position of the draw-bar on the distribution of weight of the locomotive. It was asserted by some that owing to the location of the draw-bar the tendency when the engine was pulling was to raise up the back end of the engine and increase the weight on the front wheels. Winans contended that if the draw-bar was placed at the top of the rails there would then be no tendency to either raise or lower the back end of the engine. His opponents contended that the center of the driving-axle was the neutral point, and that if the draw-bar was placed below it part of the weight of the engine would be lifted off of the back end when it was pulling, and if the draw-bar was above the center of the exle more weight would be thrown on the back wheels when the locomotive was pulling a train. It was an interesting discussion and may be offered to the young chaps as a nut to crack.

The original truck frame under the tenders of these engines consisted simply of springs, which were bolted to the tops of the journal-boxes, and the springs were connected together by heavy wrought-iron bolsters, on which the center plates rested. It was Winans' theory that the wheels of a truck should be placed as near together as they could be, so that they would act "as nearly like one wheel as possible." In accordance with this principle the truck wheels of his tenders were placed so near together that the flanges barely cleared each other.

As mentioned in the first part of this article the details of these locomotives had many interesting features and the whole machine was designed with wonderful skill and ingenuity, and the chief aim of their construction seemed to be to produce locomotives with a maximum capacity at a minimum cost. The safety of the men who had to run them seemed to have received less consideration. The object aimed at was apparently accomplished, as these locomotives certainly did a greater amount of work than any of their contemporaries and Mr. Winans made a princely fortune by building them.

As remarked in the beginning of this article, it is to be regretted that complete drawings of these interesting machines have not been preserved, but it is now probably too late to recover what has been lost.

Pensions have been paid by the Boston & Albany Railroad to an engineer and a conductor after 52 years' service in the form of a check for a year's salary and the men were retired on account of advanced age.

A strong preference for steel car frames was expressed by Mr. James Holden, Locomotive Superintendent of the Great Eastern Railway (England), in a printed interview in the "Railway Herald." He had used cars with steel frames for 30 years on the broad gauge lines of the Great Western and they are still running on the altered gauge line. He stated that some of the steel frame cars that were built in 1873 have still 50 years of life before them. The service in freight trains in England is probably much less severe than ours, yet very long life may be expected from metal frame cars here.

COMMUNICATIONS.

MORE LIGHT ON THE COMPOUND LOCOMOTIVE.

Editor "American Engineer":

Your issue for May gives a brief summary of the very interesting and admirable paper read by Prof. Smart, of Purdue University, before the St. Louis Railway Club. This paper gives data on the performance of the four-cylinder compound locomotive, not hitherto available, and of very great value if conditions under which the data were obtained were such as will make them reliable in regular road work. Some of the results are so different from those obtained on simple engines that it would seem there might have been some conditions under which Prof. Smart's tests were run that make a comparison with the results from the simple engine misleading.

The paper states that engines received steam from a 250 horsepower "Sterling" boiler, but no mention is made of the size of the exhaust opening. This, on a compound engine, has a most important influence on the mean effective pressure at high speeds, and it would be interesting to know whether the size of exhaust opening was such as could probably be used in the regular operation of a locomotive furnishing steam from its own boiler. The paper states that only one side of the engine was used in making these tests, and it would seem important to know whether the full size of exhaust opening designed for exhausts from both cylinders was used, and what the area of exhaust opening was.

The curves showing steam consumption at different speeds are exceedingly interesting, and the results shown of great importance if fairly comparable with those from the simple engine with which they are compared. It is difficult to understand why the curves for the compound at 10 and 11 inch cut off depart so widely at medium and slow speeds. At about 120 revolutions per minute they show a difference of about 3½ pounds of water per indicated horse-power per hour, while at 180 revolutions there is no difference in economy. The loss in economy is also shown to be almost entirely in the tests at 11 inch cut-off, those at the 10 inch cut-off showing a loss of but ½ pound of water per indicated horse-power from 180 to 120 revolutions, while the 11 inch cut off shows a loss of 4 pounds. With the same range of speed the loss of economy of the simple engine at both cut-offs plotted, viz.: 6 inch and 8 inch, is less than 1 pound, and is almost the same for each. Doubtless the reason for this can be explained, but it does not seem clear from the data presented.

These tests were so carefully made, and are of so much importance, that more light on points which seem obscure, it is believed, would add greatly to their value.

E. M. HERR,
Superintendent Motive Power.
Northern Pacific Railway, St. Paul, Minn., May 12, 1898.

Editor "American Engineer":

Replying to questions asked by Mr. E. M. Herr in a communication which appears in the present issue of the "Engineer," proof of which you kindly sent me, I desire to submit the following statements:

The arrangement of the exhaust on the plant in question is of necessity somewhat different from that usually employed. The exhaust passages in the saddles lead to an exhaust pipe 18 inches long, having a bridge 12 inches high. Since but one side of the engine was used, a blank flange was placed between the exhaust pipe and the exhaust passage in one saddle. Instead of a nozzle on top of the exhaust pipe, connection was made with the condenser by a 5-inch pipe about ten feet long. Condensation of the steam took place at atmospheric pressure. Although no tip was used, it is believed that the back pressure produced at high speeds by the arrangement just described was very similar to that found in service. From an examination of the cards, the amount of back pressure and its rate of increase with an increase of speed fully sustains this conclusion.

I can, at this time, offer no explanation of the results obtained in steam consumption. The conditions of operation of the tests at the slower speeds, where a decrease of economy has been noted, were entirely normal, as far as I was able to observe, and the results of the several tests were consistent, one with another.

Further investigations of the subject, which I hope to be able to make when circumstances permit, will probably furnish some additional evidence on the point in question.

R. A. SMART,
Assistant Professor of Experimental Engineering.
Purdue University,
Lafayette, Ind., May 20, 1898.

SUCCESS OF RAILROAD MEN IN OTHER FIELDS OF LABOR.

Editor "American Engineer":

It may be interesting to some of your readers to know that the old theory of railroad men that they are useless in any other field of labor than railroading is exploded by the number of ex-railroad men employed by the Peerless Rubber Manufacturing Co. in their works. Of the 350 hands employed by this company 250 are ex-railroad men, consisting of superintendents, master mechanics, conductors, engineers, firemen, baggage men, brakemen, telegraph operators and clerks. They make very valuable men, as their railroad training has taught them the value of close attention to detail, a vitally important point in a rubber manufacturing establishment.

Our assistant superintendent is an ex-railroad master mechanic. One of our most important workrooms, known as the general make-up room, is under the supervision of a prominent and successful ex-railroad superintendent. Our store house and shipping departments are both under the charge of ex-railroad conductors. The engine and boiler rooms, three distinct plants, are all handled by ex-railroad engineers and firemen. Our hose rooms have over 40 men in them from all grades of the operating service.

It was originally the opinion of the superintendent of our works that railroad men used to out of door life would not make good shop hands, owing to the confinement of indoor work. In this, however, he admits he was agreeably mistaken. A thorough trial has demonstrated that the regular life, hours and wages are very much more to their liking than the old irregular railroad life, regardless of its unexplained fascinations.

Our works are in close proximity to the eastern terminal of the West Shore Railroad, which partly accounts for the large number of ex-railroad men employed. It is quite the regular thing now for the men of the operating department of the West Shore Railroad who resign from railroad duties by request or otherwise, to at once join their brothers in the works of this company. In fact, it is quite a standing rule that the factories of this company are open to all of the West Shore men who desire to learn a trade. They have to commence on small pay of $1 per day to learn some part of the business, which is usually increased about 50 per cent. in two months, and as soon as they become proficient in their department or work, and in shop parlance, can "hold their hand," they get the regular scale of wages, regardless of the length of service.

One other good feature is their loyalty. In our experience of 18 years we have been perfectly free of labor troubles, with one exception. Last February our hose room was running night and day, and some thirty of the hands in that room decided to strike, and endeavored to induce the entire hose room to go out with them. They failed signally in their efforts, as not one of the ex-railroad men would either listen to or join them, all staying loyally at their work.

In conclusion, we cannot speak too highly of our ex-railroad men as shop hands and workmen. They are, in our opinion, a most decided success.

C. H. DALE, President.
Peerless Rubber Manufacturing Co., New York, May 7, 1898.

FAST THROUGH TRAINS ON THE GREAT SIBERIAN RAILROAD.

Editor "American Engineer":

From the beginning of April this year Moscow has been connected with Siberia by means of a fast through train. This train starts from Moscow, goes through Toula, Batraki (crossing the Volga) and Chelabinsk to Tomsk, a very important Siberian city, traversing the 2,460 miles in less than six days. The mean speed of the train is now about 18 miles an hour, but it will shortly be increased. The train is a vestibule palace-

car train, and consists of five cars, viz.: one baggage car, one dining car and three passenger sleeping cars (two second class cars with 48 berths, and one first class car with 18 berths). The train is lighted by electricity and provided with a bath room, library, cottage piano, writing table, accessories for games and gymnastics, and medicine chest. It is attended by a special rolling stock inspector. The fare for the whole journey from Moscow to Tomsk is very low, being only $34.00 in the first class sleeping car, and $21.00 in the second class sleeping car.

The first Siberian fast through train started from Moscow April 1, at 7.35 P. M., and reached Tomsk April 7, at 11.30 A. M. (St. Petersburg time), having been 136 hours on the way. The return train started from Tomsk April 9 at 9.00 P. M. and arrived in Moscow April 15 at 9.00 P. M., having been 144 hours on the way. The arrival of the first through train was celebrated in Tomsk by the local authorities and population.

As Moscow is about 400 miles distant from St. Petersburg, the whole distance from St. Petersburg to Tomsk is 2,860 miles, and can be now traversed in 6½ days.

At the end of this year the Siberian Railroad will be extended to Irkoutsk, 1,000 miles further, and the journey to that city will be about two days longer, that is not more than 8 days from Moscow to Irkoutsk.

The Chinese Eastern Railroad Company is intending to build the Port Arthur branch of the main Mandjuria line this year. This feeding branch will be very important for the purpose of construction of the main line. Mr. Gordon, the Russian agent of the Baldwin Locomotive Works, has already got an order for 20 tank-engines for the branch.

A. ZDZIARSKI.

St. Petersburg, April 30, 1898.

THE TON MILE AND ENGINE MILE IN LOCOMOTIVE STATISTICS.

By W. H. Marshall.

The great mass of statistics compiled monthly by railroad companies are intended to show the income, expenditures, earnings and the cost, in considerable detail, of the service it has rendered its patrons. Upon the general trend of these statistics the management must determine its policy in the government of the great properties entrusted to its care. The necessity of accuracy and clearness in the compilation of these accounts is apparent and needs no argument. The business of a railroad is to move passengers and freight, and the unit of valuable work is the transporting of a passenger or a ton of revenue freight one mile; consequently a company is vitally interested in the cost of these units of work. It has not been deemed feasible, however, to base all statistics directly upon these units of work, even though the determination of their cost has been and is the ultimate object. For the statistics must not only show the cost of revenue paying units in freight and passenger service, but they must be so compiled as to show what each department is doing, and, as in the conduct of its business, cars must be hauled, sometimes empty and frequently but partly loaded, it is necessary in order to determine the cost of the actual work done by some departments to take into account the cars themselves, as well as their contents. For this and other reasons, it has been customary to base much of the statistical work upon the car mile as a unit, and to compute the cost of engine service upon the engine mile unit.

In order that such statistics of engine service may be comparative from month to month, and year to year, it is evident that the amount of work performed by the locomotives for each mile run must remain reasonably uniform. At some time in the history of railroads this uniformity may have existed, but during the past decade the great increase in the size and power of modern locomotives, and the vigorous efforts made by railroad officials to give locomotives the maximum tonnages which they will haul, have so changed the conditions as to make impossible an accurate comparison of one year's work with another on an engine mile basis; whatever semblance of uniformity of conditions might have existed has been entirely wiped out. We are therefore forced to the conclusion that however valuable it might have been in the past the engine mile is now misleading when employed alone as a basis for calculation of the cost of engine service.

As an illustration of the changing conditions which destroy the value of the engine mile records, I would cite the accounts of one Western road, which show that for a certain number of

CRANK PIN AND AXLE CALCULATIONS.

Editor "American Engineer:"

Being very greatly interested and profited by Mr. Francis J. Cole's admirable articles on the question of fiber stress and the proper diameters of crank pins, I desire to present, as a contribution to the general subject, some forms and tables which I have found useful, as a step toward simplifying the question and reducing the data to a "vest pocket" basis. I therefore beg leave to submit herewith, 1st, a table giving the value of the moment of resistance (0.0982 multiplied by the third power of the diameter) from 3 inches to 9⅞ inches, advancing by eighths; 2d, a table giving the value of "P" (piston area times the boiler pressure) for various diameters of cylinders between 12 and 22 inches, and for varying pressures from 160 pounds to 200 pounds per square inch. And, two diagrams, one giving the formula for figuring crank pins and the other for driving axles, in which the foregoing tables are used.

L. R. POMEROY.

New York, May 21, 1898.

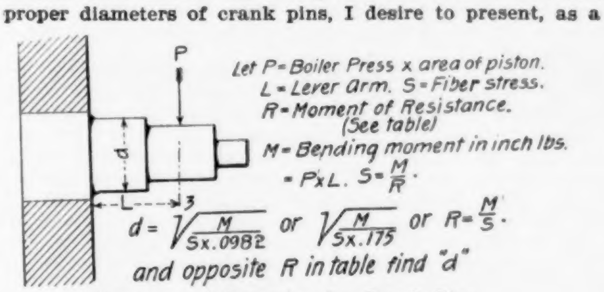


Diagram and Formulae for Crank Pins.

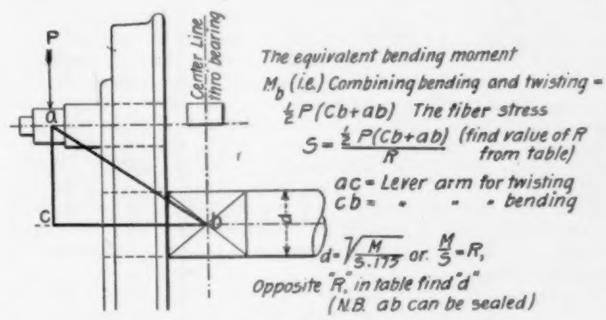


Diagram and Formulae for Driving Axles.

FIBRE STRESSES ALLOWABLE.

	Iron. Pounds.	Steel. Pounds.
Driving axles	18,000	21,000
Crank pins	12,000	15,000

MOMENT OF RESISTANCE, $R = 0.0982d^3$.

	0	⅛ in.	¼ in.	⅜ in.	½ in.	⅝ in.	¾ in.	⅞ in.
3 inches	2.65	3.00	3.37	3.77	4.21	4.67	5.18	5.71
4 "	6.28	6.89	7.53	8.20	8.94	9.71	10.51	11.33
5 "	12.27	13.32	14.20	15.25	16.36	17.51	18.09	19.83
6 "	21.21	22.60	23.97	25.42	26.96	28.57	30.19	31.80
7 "	33.67	35.40	37.41	39.36	41.42	43.46	45.69	47.94
8 "	50.27	52.66	55.12	57.67	61.04	63.36	65.77	68.63
9 "	71.57	74.59	77.70	80.89	84.17	87.54	90.99	94.54

VALUE OF "P."

Cylinder Diameter.	Area.	Piston Area by Boiler Pressure.				
		160 lbs.	170 lbs.	180 lbs.	190 lbs	200 lbs.
12 inches	113.0	18,080	19,210	20 340	21 470	22,600
14 "	153.9	24,624	26,163	27,702	29 241	30,780
16 "	201.0	32,160	34,170	36,180	38,190	40,[illegible]00
17 "	226.9	36,304	38,573	40,842	43,111	45,380
18 "	254.4	40,704	43,248	45,792	46.336	50,880
18½ "	268.8	43 008	45 696	48 384	51,072	53.760
19 "	283.5	45,360	48 195	51.030	53 865	56,700
19½ "	298.6	47 776	50.762	53,748	56,734	59 720
20 "	314.1	50,256	53,397	56,538	59,679	62,820
20½ "	330.0	52,800	56,100	59,400	62,700	66,000
21 "	346.3	55,408	58,871	62,334	65,797	69,260
22 "	380.1	60,816	64,617	68,418	72,219	76,020

CRANK PIN AND DRIVING AXLE CALCULATIONS.

months the engine miles, as compared with the same months of the preceding year, increased 18.51 per cent. In the same period the loaded car mileage increased 12.98 per cent., the light car mileage 11.23 per cent., all freight car mileage 12.47 per cent., and the ton mileage 24.95 per cent. With all engine records on the engine mile basis no cognizance would be taken of the difference in work done; if the car mileage were taken into consideration it would appear as if the engines had done less work per mile in the latter period, because the increase in car mileage is less than in engine mileage; but if the tonnage records were consulted they would show that the engines had done more instead of less work.

The question now being discussed is whether locomotive accounts should remain upon the engine mile basis, or whether in common with other statistics they should be computed upon a car mile basis, or whether all statistics should be based on the ton mile as a unit. It must be admitted that no unit can be selected which will not be open to objection. The engine mile has many, and the car mile and ton mile are not free from them. Neither of the latter two take into consideration the question of speed, though this is an important factor in the cost of service. Neither do they take cognizance of the resistance of grades and curves, of atmospheric resistance, nor of several other factors that would have to be considered if the statistics were to be comparable with those of other railroads, or comparisons made between different divisions of the same road. But before condemning a unit because it does not cover all conditions, it may be worth while to inquire whether statistics based on such a unit are worth the cost of clerical labor involved.

To illustrate: The horse power hour might be claimed to be the true unit of work from the standpoint of the motive power department, but what is its value? To obtain it speed and all the factors of train resistance must be taken into account (which is practically impossible), and when obtained it would have little direct bearing on the cost of transportation. It would be of no value outside of the locomotive department, and not so much value inside of it as might be supposed. With the ton mile unit the case is different. All engine service or operating department statistics computed on that basis can be used directly in determining the total cost of transportation, without converting them into any other units. In the writer's opinion the ton mile is a better unit than the car mile because notwithstanding the conditions which it does not take into account, the ton is always a ton, while the car may be a 30,000 lb. affair or it may be a freight house on wheels. Without attempting to go further into this phase of the question, we will accept for the present the ton mile as a superior unit to the car mile, and will consider some reasons why it should be adopted in locomotive expense accounts in preference to the engine mile.

We have stated that statistics to be of much value should show clearly the cost of the work done; that our locomotive account on an engine mile basis does not give this is certain. No better proof is to be found than in the case of modern heavy freight locomotives; we know that such engines are economical because per unit of work performed they cost less for fuel, for wages, for repairs and for oil. Accounts kept on the engine mile basis, however, do not demonstrate this fact. Per engine mile they cost more for repairs, a great deal more for fuel and at least as much per mile for wages; thus the engines that are the most economical to the company appear most extravagant on the records, and in order to demonstrate their economy we must determine the tonnage hauled and from the present engine mile accounts deduce the cost of service on the ton mile basis. It would, therefore, seem as if these accounts might be originally computed on this basis.

To illustrate this condition of affairs I would cite the performance of some 17x24 inch, and 19x26 inch engines in freight service on a certain division of the Chicago & North Western Railway in February, 1898. The 17-inch engines are more numerous than the 19-inch, but there were enough of each to give a fair comparison. The figures are as follows:

Comparison of 17x24 and 19x26 inch engines for February, 1898:

	17 x 24.	19 x 26.
Ton miles	26,789,289	17,314,508
Train miles	67,450	22,575
Engine miles	74,195	24,713
Average tons per train	397	767
Coal used (tons)	3,780	1,542

Engines.	17x24-inch.		19x26-inch.	
	Engine mile basis.	1,000 ton mile basis.	Engine mile basis.	1,000 ton mile basis.
Total cost of engine service in cents, including engine crew wages	17.73	49.03	20.85	29.67

In the above statement the coal, oil and waste, dispatching or hostling and engine crew wages are exact. The repairs and round house labor are estimated because the large engines are new, and accurate figures on the repairs in particular were not available. The cost of repairs estimated for the larger engines was much greater per engine mile than for the smaller ones, and was based upon what other large engines are known to be costing. Over 80 per cent. of the costs above shown are actual, and the possible error in the estimated items could not influence the general result. The figures are striking because they show that while the operating expenses of the large engines were 20.85 cents per mile, as against 17.73 cents for the smaller, or 3.12 cents in excess, they only cost 29.67 cents per 1,000 ton miles, as against 49.03 cents for the smaller engines. In other words, on the engine mile basis they cost 17 per cent. more to operate and on the 1,000 ton mile basis they saved 39½ per cent., as compared with the 17-inch engines. This statement shows how misleading the engine mile accounts may be in some cases.

The cost of fuel is such a large item and the necessity of economizing in its use has become so urgent that many railroads in order to achieve the desired results have found it necessary to put the cost of fuel upon the ton mile basis as far as the individual records of the engine men are concerned. The road with which the writer is connected adopted this course some years ago, and with decidedly beneficial results. On the engine mile basis the smaller the train hauled the more favorable the enginemen's records appeared; consequently there was no incentive for an engineer to handle trains that called for the maximum capacity of the engine. By placing the individual coal records upon the ton mile basis all this was changed, for it was at once shown that, other things being equal, the engineer hauling a light train could not hope to show up as well as a man hauling a heavier one. The heavier the train the less the coal consumption per hundred ton miles, consequently there is every inducement for the engineer to handle the heaviest train with which his engine was capable of making the speed required by the operating department. So great have been the gains from the introduction of the individual coal records based on the ton mile that it would seem desirable to have the total monthly performance shown in the same way. Though this is not done on the summary, the performance of each division is in reality checked up by the ton mile figures.

Not the least of the advantages which comes from placing the coal record upon the ton mile basis is the unity of purpose which it helps to give to all officers in the operating and mechanical departments, and to many of their employees. There may be many men who are broad-minded enough to pursue a course which will make their own records appear in an unfavorable light, though resulting in economy to the company they serve, but we can hardly expect that every man will so act. Yet that is exactly what every official and every engine crew ought to have done under the old method of computing the record of fuel on the engine mile basis. If he had a sufficient insight into the economies of railroad operation to realize that a heavier train was more economical to the company it was certainly his duty to do all he could to bring about the heavier loading of engines, even though his own accounts were going to show heavier expenses per engine mile. But if a motive power official considered only the showing of his own department he would have sought the light train loading, while the operating department official, also having in mind only his department, would have endeavored to increase the train loads. The interests of the two departments were then not identical. By placing the fuel account upon a ton mile basis the mechanical and operating departments are not only brought together on an economical course, but they obtain the co-operation of every conscientious and careful engine crew.

The advantages of placing the fuel upon the ton mile basis have been so apparent that some officials have been led to advocate showing all other locomotive expenses upon the same basis on the monthly performance sheet, and there is much to be said in favor of this plan. Engine crew wages and repairs are two very large items in the total cost of locomotive expenses, and the reasons for placing them upon the tonnage basis are of much the same character as outlined in the case of fuel, except that the showing on these items would probably influence and impress officials rather than employees. When operating officials are making strenuous efforts to increase the tonnage of trains we sometimes hear mechanical officials say their engines are so heavily loaded that the cost of repairs is increased, and some who have not gone to the root of the matter are inclined to think the company is losing more in the additional cost of maintaining the locomotives than is saved in other directions by the heavy tonnage assigned to the engines. If repairs were computed upon the ton mile basis such officials would quickly find out that the heaviest trains which their engines could haul would be best for their records and

that every light tonnnage train that passed over the road was detracting from the showing of the motive power department at the end of the month or year.

The cost of engine crew wages is one which, while it may remain constant per engine mile under the schedules that may now be in force, should be put upon the tonnage basis in our accounts, if for no other reason than to give us constantly an example of the economy due to heavier trains by showing how this item reduces per ton mile as the trains increase. The items of oil and waste, dispatchers and wipers, and round house laborers can all be computed with advantage upon a ton mile basis.

While these advantages are conceded, there is, however, something to be said in favor of retaining the present accounts, and in fact, showing the expenses both on an engine mile and ton mile basis. For instance, let us take the dispatching or hostling of engines. It costs no more in hostlers' wages for handling a large engine at terminals than for a small one, and if this account was placed on the ton mile basis there would be a tendency for it to decrease with every increase in the average weight of the train, whether such an increase was due to a heavier rating of the engines, a better average loading by the operating department or any other local or general condition. The mechanical department might thereby claim for itself an economy which should not be credited to it; even if it did not do this, it is apparent that the account would not show upon its face the actual cost of hostlers' services per engine handled, and whether it was in reality increasing or decreasing could not be shown except by a special statement. Others items would be equally in need of a side light thrown upon them in the shape of cost per engine mile. In fact, this necessity of a side light is found even in our individual fuel accounts, and perhaps I cannot do better than to cite an actual case. The attached table is taken from the fuel record of a number of men who are supposed to be in strictly comparative service:

Engine Crew.	Engine Mileage.	Tons of Coal.	Miles run per Ton.	Ton Miles.	Pounds of Coal per 100 Ton Miles.	Average Weight of Train.
1	2,584	135	19.1	1,442,762	18.7	558
2	2,042	127	16.0	1,238,428	20.5	606
3	2,512	146	17.2	1,295,295	22.6	516
4	2,837	162	17.5	1,383,900	23.4	488
5	2,398	126	19.0	966,028	26.0	403

It will be seen that the average weight of trains hauled by them during the month varies from 606 to 403 tons, and that the man with the lowest tonnage is also the most expensive on coal per hundred ton miles; this may be expected to some degree, but in this particular case it looks as if he was more expensive in fuel than his reduced tonnage would warrant. Had we no account on the engine mile basis a decision might not be reached with any degree of certainty, but by looking at his miles run per ton we find that he did not run as many miles as the engineer who had a 558 ton train. The suspicion therefore raised by his record on hundred ton miles is confirmed, and when asked by his master mechanic why he did not do better he cannot make his light train an excuse.

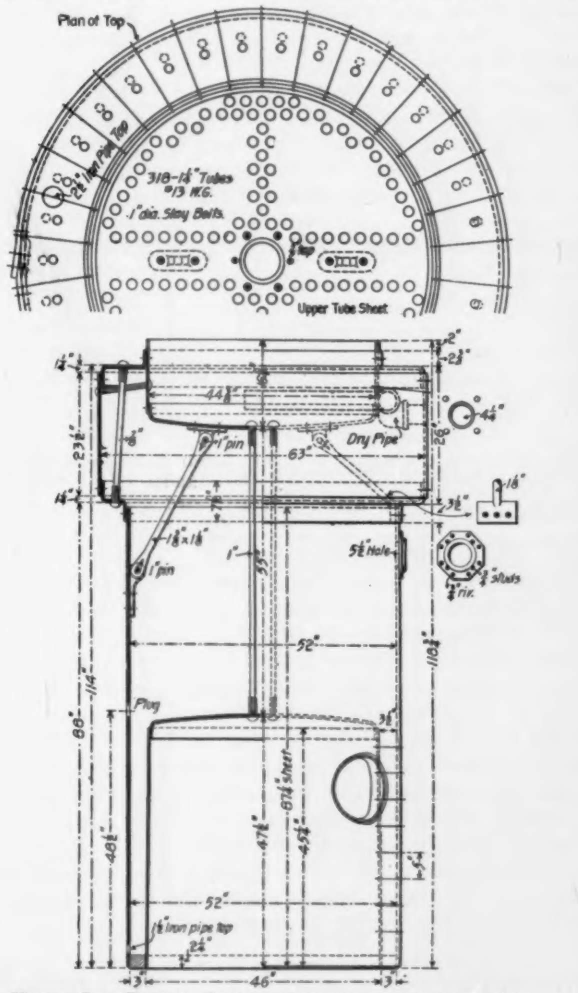
The same argument in a measure applies to the other items that enter into locomotive expenses. If we should place them all upon the ton mile basis and with the incentive thus given, the operating and mechanical departments should both work hard to increase the average tonnage of all freight trains, the locomotive accounts would be certain to show an economy over previous records. Whether the economy is all it ought to be under the changed conditions cannot always be known without consulting the engine mile accounts; for this reason the writer favors showing the accounts both on a ton mileage and engine mileage basis.

There is one other matter in connection with this subject that is seldom touched upon, but which is nevertheless of considerable importance; this is the separation of the expenses of passenger and freight service. The mileage in each service is given on monthly performance sheets, but the expenses of the two services are not shown separately. The cost on the ton mile basis of both fuel and repairs is greater in passenger than freight service. If the ratio between the tonnage in the two services does not remain constant the combined costs of engine service will fluctuate without any apparent reason. The separation of the expenses is desirable from some standpoints, but whether the additional labor is justified each road must judge for itself. It appears clear to the writer, however, that with a separation of passenger and freight engine expenses and the costs shown both on the ton mile and the engine mile basis, the actual cost of each service would be obtained and a minute analysis of all items would be possible. Whether the separation of the passenger and freight engine expenses would be justified may be an open question, but it appears to be essential to compute expenses on both engine mile and ton mile units.

BOILER FOR STEAM MOTOR CAR—NEW ENGLAND RAILROAD.

The chief of the general features of the steam motor car, built by the Schenectady Locomotive Works for the New England Railroad, were presented in our issue of November of last year, and we now show the details of the construction of the boiler.

This is an upright, fire tube, cylindrical boiler with an en-



Motor Car Boiler, Schenectady Locomotive Works.

larged steam space in the form of a drum. The chief dimensions are as follows:

Outside diameter ....Top, 63 in.; bottom, 52 in.
Steam pressure ....200 lbs.
Firebox, diameter ....45⅝ in.
" depth ....47½ in.
Water space ....3 to 3½ in. all around
Tubes, 1¼ in., number..318
Total heating surface ....643 sq. ft.
Grate area ....11¼ sq. ft.

The firebox is stayed with 1-inch Taylor iron staybolts, and the method of staying the other surfaces is clearly indicated in the drawing. The upper tube sheet is dished and braced to the iron sheet and to the shell and is riveted to a welded ring to form the throat connection to the top of the shell. The dry pipe is in the form of a semi-circle of 3-inch wrought iron pipe, which is 40 inches long before bending and lies against the throat connection sheet at the top of the boiler. It is perforated by 400 ¼-inch holes in four rows of 50 holes each in its upper surface. The same drawings were used in the construction of the boiler for a similar car for the Erie Railway.

The Richmond Locomotive and Machine Works has just received by cable an order from the Finland (Russian) State Railway for seventeen compound locomotives. This is a high tribute paid to American industry, the Richmond Locomotive and Machine Works being wholly without influence in Russia and the order being given entirely upon the merits of workmanship.

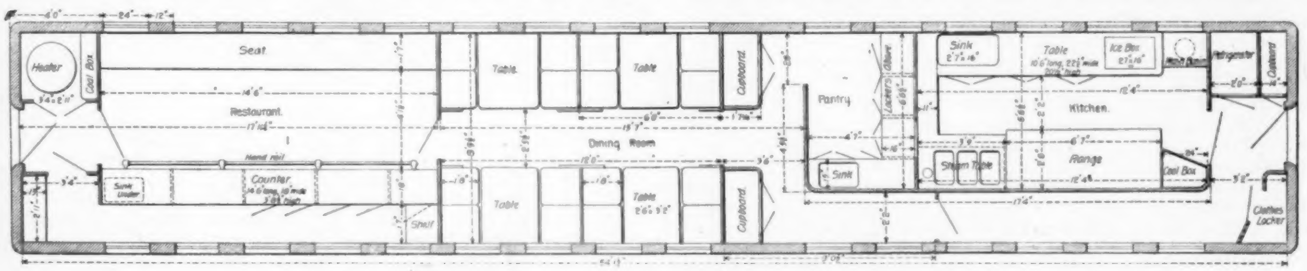
Mr. Daniel S. Newhall, Assistant Secretary of the Pennsylvania Railroad, has been appointed Purchasing Agent of the road.

COMBINED DINING AND RESTAURANT CARS—INTERCOLONIAL RAILWAY OF CANADA.

We have received from Mr. F. R. F. Brown, Mechanical Superintendent of the Intercolonial Railway of Canada, a floor plan of an interesting arrangement combining a regular dining car, with its appurtenances, with a restaurant room. The drawing presents the chief dimensions and shows the arrangement of the car, the passage ways and the accommodations in such a way as to require no explanation.

Three of these cars were recently converted from first class passenger coaches and it was a difficult matter to provide for the kitchen and accommodation for both first and second class passengers in cars only 54 feet long, especially when the kitchen, pantry and cupboards take up nearly half of the length. One of the conditions imposed was that a standard, full-sized range, with steam table and other fittings, were to be used, in order that these may be used again in case it was decided to replace these cars with first class, full length dining cars. The same kitchen and refrigerator equipment would be put into the larger cars, and the 18-foot counter from the restaurant end would also be used.

In the dining compartment is room for but four tables, yet their arrangement seems excellent for such a limited accommodation. The cars are to be considered as experimental, and while ample to meet the requirements during winter months it is possible that larger ones may be built when the demand increases sufficiently. It is understood that no changes were made in the framing or other parts of the car bodies, except where necessary to put in the new fittings.



Combined Dining and Restaurant Car, Intercolonial Railway, Canada.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads — Second Series — Chemical Methods.

XXIV.—Maumené's Test for Oils.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

Explanatory.

Perhaps no class of commercial products are more easy to adulterate or falsify, and certainly none are more difficult to detect adulteration in, than the fixed animal and vegetable oils. The very large number of kinds of oil in the market, differing widely in price, furnishes the opportunity for mixing, with the expectation of selling the mixture at the price of the more expensive constituent, while the fact that almost all of these oils mix readily with each other, even without the application of heat, makes adulteration simple and easy. It is only necessary to add the various oils the mixture is designed to contain, to a tank and stir, and you have a quantity of oil ready for barreling. Furthermore the following facts, viz., that very few of the fixed animal and vegetable oils have any characteristic odor, color or taste, that they differ very slightly in specific gravity, that their optical behavior does not differ sufficiently to make the detection of adulterations or mixtures easy by this characteristic, and that the saponification equivalents of most of these oils are so nearly alike makes the examination of oils for admixtures or falsifications one of the most difficult that comes to the commercial chemist. Notwithstanding, however, the obstacles above mentioned, a number of methods for testing oils as to their purity or freedom from falsification or admixture, have been proposed, some of which are quite successful. Among these may be mentioned microscopic examination, applicable to fats which crystallize; relative solubility of these substances in different menstrua, applicable in a limited way to all fats; saponification, applicable to all mixtures of saponifiable and non-saponifiable oils; melting and chilling points, applicable in a confirmatory way, in a very large number of cases; color reaction with oil of vitriol, of limited use and value; elaidin test with nitric acid, likewise of limited use and value; the iodine and bromine absorption tests, which are of very wide application, and of much value, and the nitrate of silver color reaction, applicable to certain burning oils, in which it shows quality, rather than admixture.

This list might be very much extended, and still not exhaust the subject, but it is wide of our present purpose to write a treatise on oil testing. We simply want to describe what in our experience has been found to be one of the best of the tests for the fixed animal and vegetable oils. It is fair to say that the kinds of test to be applied in any case, are generally determined by the previous history of the sample, or by knowledge or suspicion, as to what may be present, and that any or all of the above tests, or even other, may be used in our laboratory, in working on a sample of oil. If we may trust our experience, no single test is final, that is, no single test is known to us, by the application of which it is possible to say that a sample of any oil is pure and free from admixture. On the other hand the Maumené test, described below, is, so far as our experience goes, the best single test now known. It is susceptible of as wide application as any single test known to us, and its results are as valuable. Still further the ease of its application, the simplicity of the manipulation, and the rapidity with which results can be obtained, all recommend it to favor.

Operation.

Have a bottle of concentrated oil of vitriol, such as is described below, at the temperature of 80 degrees F. for all oils which are limpid at that temperature. For fats having higher melting points, a higher temperature may be used. It is essential that the fat to be tested should be limpid, and the temperature necessary to secure this result may be used. Measure with a pipette into a beaker, which must be perfectly dry inside and outside, such as is described below, 20 cubic centimeters of the oil to be tested, which must be free from moisture. In some cases, as will be described below. less must be used. Introduce a thermometer reading to at least 212 degrees F., and by warming or cooling as may be necessary, bring the oil, beaker and thermometer to the same temperature as the acid. Now by means of a pipette, add to the beaker 10 cubic centimeters of the acid. Then grasping the beaker near the top, between the thumb and first two fingers of the left hand, so as to leave the bottom untouched, and at the same time inclining the beaker a little, stir with

the thermometer, so as to produce as intimate a mixture of the oil and acid as is possible, in as short a time as is possible. A reaction immediately follows, accompanied by the development of considerable heat. Observe the thermometer from time to time, for which purpose a momentary cessation of the stirring is necessary. The temperature will be found to rise gradually, until a maximum is reached. Observe and make a note of this maximum temperature, and treat the figures as described under "Calculations." A little experience enables duplicate determinations to be made, which agree within a degree or two, in the maximum temperature found.

Apparatus and Reagents.

Plain or lipped beakers about two and one-half inches high, and an inch and three-quarters in diameter at the bottom, are a convenient size for this test. When a number of different ones are used, it is essential that they should be very nearly alike in dimensions and weight. Either ordinary chemical or milk scale thermometers may be used. The bulb holding the mercury should be so short that the oil and acid completely cover it. Where a number of different thermometers are employed for this work it is essential that they should read alike, both at the temperature of starting the operation and at the maximum temperature. It is hardly safe to use them as they are received from the market, without testing.

The quality of the oil of vitriol employed is of the greatest possible importance. It is rare that two different bottles or two different carboys of acid will give exactly the same results on the same sample of oil, and concentrated C. P. sulphuric acid gives very wild results. Some experiments have been made looking toward finding an explanation of these irregularities, with the idea in mind of making it possible to use any acid, but these experiments have not yet led to any satisfactory conclusion. Accordingly it has been found desirable to test the acid from a number of different bottles or carboys, with a sample of any oil known to be pure, and set aside for future use the bottle or carboy which gives with this pure oil, a maximum temperature, corresponding most closely with previous practice. If this bottle or carboy is kept carefully stoppered the figures given by it can be used as long as the supply lasts. When a new supply is needed, the same process of selection is repeated, either with or without change of the figures showing maximum temperature, as may be shown by the experiments.

Calculations.

The difference between the initial temperature used at starting the experiment and the maximum temperature found, which may be called for convenience the "rise in temperature," are the figures which are useful in the calculations. It is believed that each fixed animal and vegetable oil, in a state of purity, has its own characteristic rise in temperature when treated as above described. If it is desired, therefore, simply to know whether a sample of oil of any kind is pure or not, it is, so far as Maumené's test is concerned, only necessary to know whether the rise in temperature given when a sample of the kind of oil in question, which is known to be pure, is the same as that given by the sample about which information is desired, both being tested as described above. If the figures given by the pure and the unknown sample are the same, then so far as Maumené's test can tell, the unknown sample is pure. For example, if pure lard oil shows a rise in temperature when tested as above described of from 78 to 80 degrees F., and no other known oil gives this rise in temperature, it is deemed safe to assume that any commercial oil which gives this rise in temperature is, so far as Maumené's test can show, pure lard oil. As will be explained below, even though the figures given by Maumené's test are satisfactory, the sample in question may not be pure oil, and further tests may be needed to decide the point. Here we are only illustrating how to use the Maumené test. This test likewise has a still further use. If it is known that a sample of oil is made up of two kinds of oil, and if the rise in temperature characteristic of each of the constituents is likewise known, the proportions of each in the mixture may readily be obtained as follows: Assume the rise in temperature of one of the constituents to be (a) degrees F. and of the other (b) degrees F., while the rise given by the mixture is (c) degrees F., what is the proportion of each in the mixture? This may readily be found by substituting the figures found, in the following formula:

$\frac{100\,(c-a)}{(b-a)}$ = per cent. of oil (b), and this being known, the percentage of the other constituent is found by subtracting from 100. The derivation of this formula is readily determined algebraically, and is perhaps not necessary here.

Notes and Precautions.

It will readily be noted that this test is based on the fact that strong oil of vitriol mixed with the animal and vegetable fixed oils, develops heat. Considerable work has been done trying to explain the reaction between the oil and the acid under these conditions. Those interested will find this here and there in chemical literature. It is also clear that anything which affects the generation of heat or causes loss of heat will affect the result. The method of stirring affects the generation of heat. Beginners are apt to get results with the self-same oil and acid differing from 5 to 10 degrees, apparently due to lack of skill in securing an intimate mixture of the oil and acid by stirring. Even different experienced operators using the same materials frequently get results differing a degree or two. It is almost impossible to explain in words how to stir, but perhaps the words, "energetic," "rapid," and "thorough," in opposition to "sluggish," "slow," and "incomplete," best express the kind of stirring required. The length of time from the beginning of the operation to the final reading of the thermometer has an important influence on the result, apparently due to loss of heat during the operation. If the stirring is properly conducted, of course the length of time required is a function of the speed of reaction between the oil and acid, and this varies with different oils. With oils of which 20 cubic centimeters are used for test as is described above, the reaction with proper stirring should be complete, and the final reading made in from a minute to a minute and a half from the time the stirring begins. Loss of heat may also be occasioned by improper touching of the lower part of the beaker, by a draught of air, by conducting the test in too cold a room, and by using a beaker which has not been properly dried on the outside. Still further, the importance of having the oil to be tested free from moisture even in very minute amounts, will not escape attention, since the great heat developed by the mixing of oil of vitriol and water is so well known.

A number of experiments have been made looking toward diminishing the loss of heat by enclosing the beaker in some non-conducting medium, such as cotton wool. No valuable results have been obtained from these tests, apparently because when the test is properly conducted, the loss of heat during the required time is so small that it can be ignored. As would be expected, the appliances for surrounding the beaker with non-conducting material complicate the manipulation somewhat.

As has been stated, the energy of the action of the acid on the oil varies with the kind of oil. With the non-drying oils, such as olive, lard, neatsfoot, tallow, etc., action is slower. With the semi-drying oils, such as cottonseed, it is more rapid, while with the drying oils, such as linseed, poppy, and some of the fish oils, it is still more rapid and energetic. Also the rise in temperature characteristic of the various kinds of oil seems to follow the same law, as the energy of the action, viz., the non-drying oils give the lowest rise in temperature, while the drying oils give highest. Another interesting observation in this connection is that with all oils, so far as our observation goes, when the temperature reaches somewhere from 200 to 220 degrees F., and with some oils below these temperatures, a new reaction begins, resulting in the disintegration of sulphurous acid (SO_2). This interferes with the test by frequently causing the material to foam up and run over the beaker. It is, accordingly, necessary when testing such oils as give high figures to use less of them for test. The method described above applies in amount of oil taken for test, to the non-drying oils. When testing the drying oils, or such as give a high rise in temperature, use 5 cubic centimeters of the oil instead of 20, as with the non-drying oils. The other items of the test are alike in both cases, except that in calculating percentages figures obtained when using 20 cubic centimeters of an oil cannot be used with figures obtained when using 5 cubic centi-

meters of the second oil. It is obvious that when calculating percentages the figures used must be obtained from each of the oils under the same conditions in every respect.

It is clear that when several oils give figures nearly alike, as is the case with olive, lard, tallow oil, etc., the certainty with which information as to the purity of these oils can be obtained by means of Maumené's test is diminished. For example, it would be practically impossible by means of this test alone to say whether a sample of so called olive oil was mixed with tallow oil or not, since the rise in temperature characteristic of these two oils is so nearly alike. On the other hand if a sample of so called olive oil was in reality a mixture of olive oil and cottonseed oil, it would be easy by means of this test to say that the so called olive was not pure olive oil, since cottonseed oil gives so much higher rise in temperature than olive. Still further, it is obvious that the constituents of a mixture being known, the percentages in the mixture are much less accurately calculated if the two constituents give figures for rise in temperature nearly the same than if these figures are wide apart.

While Maumené's test does give some considerable help in identifying the kind of an oil which one may have in hand, provided that oil is pure, it should be clearly understood that it throws very little if any light on the identity of the oils in a mixture. And it will not escape notice that by proper mixtures the characteristic rise in temperature of many oils may be very closely approximated. For example, a mixture of some of the refined petroleums, which give almost no rise in temperature under Maumené's test, and cottonseed oil, might be made of such proportions as would make the mixture give the rise in temperature characteristic of olive oil. Fortunately for those who have to do with checking the adulterations and sophistications of the market, Maumené's test is not the only one that can be used in such cases. Fortunately, also, for those who have to do with not only the testing of oils, but also the practical use of them, the fixed animal and vegetable oils which are most valuable for lubrication and burning at the present time, give with Maumené's test figures which are near the lower end of the series, while the fixed animal and vegetable oils which can commercially be used as adulterants of these at the present time give figures much higher up in the series. Also the most successful drying oils give figures very high in the series, while a portion at least of the adulterants of these give figures considerably lower down, so that while the indications of Maunené's test, as has already been stated, cannot be regarded as final in regard to any oil, it still does give much very valuable information.

It will be evident from what has preceded that figures obtained by any operator while using Maumené's test are a function not only of the acid, the thermometer and the beaker employed, but also in some degree of the operator and the surroundings. Still further, our experience indicates that even with pure oils of any kind the figures are affected by the previous history and quality of the sample. Old oils do not give exactly the same figures as fresh ones, an inferior grade of an oil does not give exactly the same figures as a better grade, a pure oil consisting principally of olein does not give exactly the same figures as one containing considerable stearin along with the olein. In view of these facts a list of the figures characteristic of various oils is not of very great value. It may be said, however, as a general guide, that pure winter strained lard oil of the best grade made from the fat of corn fed animals should, when tested as above described, show a rise in temperature of from 78 to 80 degrees F., while pure raw linseed oil, properly settled and free from the oil of other seeds, should, using 5 cubic centimeters for a test, show a rise in temperature of from 105 to 106 degrees F. These figures should only be taken as a general guide. The only safe plan for an operator using Maumené's test to follow is to provide himself with samples of the various oils he may be called upon to test, which he knows to be pure and of the proper grade and previous history, and to constantly use these oils as a check in his daily work. The obtaining of such samples is not always easy, but they seem to be an essential, and if we may trust our experience, it is worth the expenditure of considerable energy to secure them.

That "semi steel" is really not steel at all but toughened cast iron is the claim made by Mr. A. E. Outerbridge in regard to the alloy that is used to some extent in the manufacture of M. C. B. couplers. "Semi steel" is the result of mixing steel scrap with pig iron in a cupola and, according to Mr. Outerbridge, the identity of the steel is entirely lost and that of the cast iron completely preserved, the resultant metal being simply a strong close grain cast iron. The statements have not yet been challenged.

RECONSTRUCTING LOCOMOTIVES.

By Francis R. F. Brown.

The advantages of reconstructing or modernizing locomotives are now becoming so generally recognized, and appear to be, deservedly, growing so much in favor, that a few words on application and results obtained, may be of use to some of the readers of the "American Engineer." Every railroad owns some old or obsolete locomotives. The wealthier roads can afford to dispose of these and purchase or build modern machines, but to the majority of roads the question of reconstruction might be well worth consideration.

Locomotives from fifteen to twenty years old may, generally speaking, be reconstructed, the chief parts for renewal being the boilers and the cylinders. The boilers, because eighteen years may be considered a fair average life for them; during this life the fire box will not only have been frequently patched, but it will have been renewed once, or more than once, and boilers as built eighteen years ago were made of iron and the plates were what are now considered to be too light, they were also small in size, and carried a low pressure of about 135 to 140 pounds per square inch. The new boilers might be of the extended wagon top type, and of as large size as the frames and axles will permit; the boiler pressure should be from 160 to 180 pounds per square inch, according to circumstances.

The cylinders should be renewed, because twenty years or so ago the independent saddle type of cylinder was largely used, they were born with a disease to develop sooner or later—generally sooner—viz.: "loose cylinders;" the older they grew the worse became the disease, and the cure for the disease is the application of the half saddle type. The new cylinders should be either of reduced size or, at the most, of the same size as the old ones, which circumstances, such as strength of frames, and motion, size of axles, etc., will govern; because, generally speaking, till recent years all locomotives were more or less over-cylindered. The new cylinders should be provided with ample steam and exhaust ports and passages, and the valves should be of a modern balanced type.

The frames should be strengthened by reinforcing the splice, and main panel, and adding cross braces and a strong and heavy back casting well secured. Cast iron running boards, stronger crank pins, and solid end, fluted side rods should be adopted. For an illustration of how frames may be strengthened see "National Car and Locomotive Builder" for March, 1895.

By this process of reconstruction a new life may be given to the locomotive, and its haulage capacity increased from 15 up to 35 per cent., and the cost of the work is such as to recommend it for careful consideration.

An eight-wheeled road engine, of about 1880 and later date, with 16 or 17 inch cylinders, may be reconstructed on the lines as outlined above for about $3,250 to $3,600, and an 18 inch engine of the same type for a sum not exceeding from $3,750 to $4,200—these amounts including the necessary heavy repairs resulting from such reconstruction.

As one example of reconstructing passenger engines of the eight-wheel type, I will cite the following: The original locomotive for our notice had 18 by 24 inch cylinders; driving wheels 69 inches in diameter; boiler with 52 inch shell of the old wagon top style; pressure 140 pounds per square inch; total weight in working order was about 85,000 pounds, the frames were light, the axles 8 inches in diameter, and the cylinders of the old independent saddle type, with its characteristic defects. In reconstruction the frames, wheels, tires, axles, and motion were used again; and new boiler, cylinders, springs, spring-gear, crank pins and side rods were supplied.

In deciding upon the size of the boiler and the cylinder proportions, the strength of the frames and size of axles received careful consideration. The boiler adopted was of the "Bel-

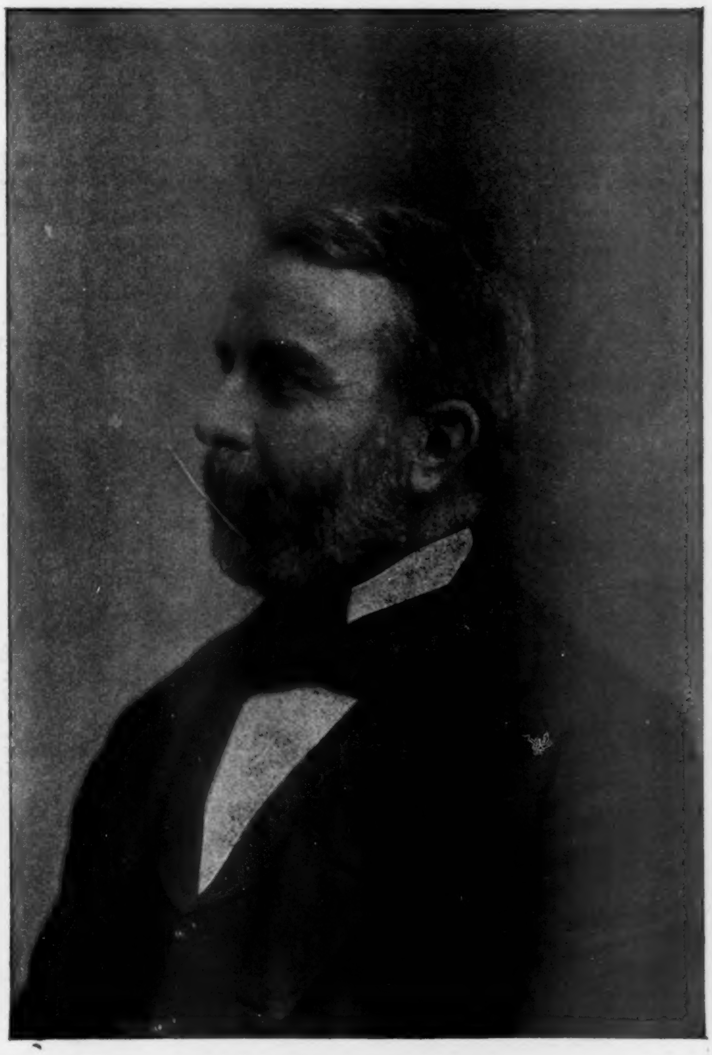
paire" type, with 56 inch shell and a working pressure of 180 pounds to the square inch, and still bearing the light frames in view, the cylinders were made 17 by 24 inches, and of the half saddle type. Balanced valves of the "American" type were put in. The engine as reconstructed weighed 110,500 pounds in working order, of which 36,500 pounds were on the truck and 74,000 pounds on the drivers. The gain in tractive power was about 35 per cent. Several locomotives were thus reconstructed, and after being in operation for about three years, on a mileage of 378,100 miles, the cost of maintenance for running repairs was $6,261.38, or about 1.65 cents per mile. In fuel consumption, when running against the original engine with 18 by 24 inch cylinders, and on the same trains, and with the same number of coaches, it was found that the reconstructed engine ran an average of 36 miles to a ton of coal, as against 31¾ miles run by the original engine to a ton of coal, showing a saving of 13 per cent. in fuel in favor of the reconstructed engine, while on a heavier train they were demonstrated to make better time with 8 coaches, than the original engine could do with 6 coaches.

The question of reconstruction is one to which the mechanical officers of roads which have not much money to spend on new locomotives may well devote some of their time and experience. To roads not possessing modern equipped boiler shops, there are always the locomotive building establishments, from which new boilers and cylinders, side rods, etc., of modern design and make may be procured at reasonable rates, and the moderate expenditure involved in reconstruction should recommend itself to the favorable consideration of "The Management," always providing that the management has advanced beyond the stage of believing that the weight of train to be hauled depends upon the inches of the cylinder, and of insisting on a cylinder larger than is necessary or advisable to accompany the larger boiler, and thereby defeating the object of increased haulage power, combined with a decreased fuel consumption and cost of maintenance, and causing a repetition of the old defect, an over-cylindered engine, with the added drawback of light frames, and running gear, which were the bones of the original locomotive.

SAMUEL ROGER CALLAWAY.

The New York Central & Hudson River Railroad, in calling Mr. Callaway to its Presidency, has made a most wise and fitting selection.

He began his railroad career at the age of thirteen, as an indentured apprentice office boy in the office of the Treasurer of the Grank Trunk Railway of Canada, and it is interesting to know that his first year's salary amounted to $100. At the age of nineteen he was a clerk in the office of the Great Western Railway at London, Ontario, from which he was promoted to the position of train master and private secretary to the General Manager. In 1874 he came to the United States as Superintendent of the Detroit & Milwaukee Railway, and four years later he accepted a similar position with the Detroit, Saginaw & Bay City Railroad. He was General Manager of the Grand Trunk lines west of the St. Clair River from 1881 to 1884, and at the same time held the office of President of the Chicago & Western Indiana Railroad. He was elected Vice-President and General Manager of the Union Pacific in 1884, and held the office for three years, retiring to take the presidency of the Toledo, St. Louis & Kansas City, and under his direction the company was reorganized and the road practically rebuilt. In January, 1895, he was elected President of the New York, Chicago & St. Louis, and in August, 1897, he was selected to succeed the late D. W. Caldwell as President of the Lake Shore & Michigan Southern Railway, and April 27, 1898, he was elected President of the New York Central & Hudson River Railroad.



Samuel Roger Callaway.

The attainments and experience of Mr. Callaway are such as to render the road subject to congratulations on the appointment, and surely no better opportunity could be offered him for the exercise of his abilities. His many friends will join the "American Engineer," to which he has been a subscriber for a number of years, in the hope that he will not end his career by overwork, as President Newell did, but that he will live many years to enjoy the fruits of his conscientious efforts.

Mr. John M. Toucey, General Manager of the New York Central & Hudson River Railroad, has resigned and will retire from active railroad work to enjoy a well earned rest. He is 70 years of age and entered the service of the Naugatuck Railroad as station agent about 50 years ago. He went to the Hudson River road in 1855, and in 1862 was appointed Assistant Superintendent. From 1867 to 1881 he was Superintendent of the Hudson River Division of the New York Central Railroad, and from 1881 to 1890 was General Superintendent of the entire system. He was appointed General Manager in 1890, and has held the office continuously since.

The Young Men's Christian Association of Dunkirk, N. Y., is the recipient of a generous gift in the form of the Brooks homestead, in Dunkirk, valued at about $90,000. The property was given by the heirs of the late Horatio G. Brooks, the founder of the Brooks Locomotive Works, and it is to be used as hospital, library, educational and recreation purposes by the association.

The Carlisle Manufacturing Company's plant at Carlisle, Pa., which has been idle for several years, has been bought by Philadelphians, and will be equipped with new machinery. In addition to frog, switch and metallic tie work, projectiles will be made for the Government.

The Cramp Ship Building Company recently closed a contract with the Russian Government for the building of a heavy armored battleship of 12,500 tons displacement and a speed of 18 knots per hour, to be sustained for a trial of 12 hours, and for an armored cruiser for 23 knots speed and 6,100 tons displacement. These will be the first Russian war vessels to be built at any foreign shipyard.

OUR DIRECTORY

OF OFFICIAL CHANGES IN MAY.

Baltimore & Lehigh.—Mr. G. W. Seidl has been appointed Master Mechanic, with headquarters at Baltimore. The office of General Foreman of Locomotive Repairs has been abolished.

Brockville, Westport & Sault Ste. Marie.—At a meeting of the Directors, recently held in Brockville, Ont., Mr. James G. Leiper resigned as President and was succeeded by Mr. Evans R. Dick, of 310 Chestnut street, Philadelphia, Pa.

Chattanooga Southern.—Mr. E. H. Harding has been appointed Master Mechanic, with office at Chattanooga, Tenn., succeeding Mr. J. H. McGill, resigned.

Chicago, Burlington & Quincy.—Mr. N. E. Jennison has been appointed Assistant Purchasing Agent, with office in Chicago, succeeding Mr. George G. Yeomans, promoted.

Chicago & South Bend.—Mr. C. L. Milhouse has been appointed General Manager, with office in South Bend, Ind., succeeding Mr. C. W. Stover.

Cincinnati, Portsmouth & Virginia.—Mr. Evans R. Dick has been elected Vice-President, with office at Philadelphia, Pa., vice Mr. James G. Leiper, resigned.

Detroit & Lima Northern.—Mr. J. R. Hawkins is General Superintendent, with office at Detroit, Mich. The office of Mr. C. H. Roser, Chief Engineer and Purchasing Agent, is now at Detroit. Mr. J. W. Stokes has been appointed Master Mechanic, with headquarters at Tecumseh, Mich.

Flint & Pere Marquette.—Mr. W. B. Sears, formerly Chief Engineer, has had his title changed to that of Consulting Engineer, his headquarters remaining at Saginaw, Mich. Mr. G. M. Brown, heretofore Superintendent of Roadway and Structures, has been made Engineer in charge of bridges, culverts, buildings, interlocking, new construction and standards of maintenance, with office at Saginaw. Mr. E. Treadwell has been made General Roadmaster, in charge of maintenance of roadway, with office at Saginaw. Mr. H. E. Moeller, heretofore Assistant Passenger Agent, has been appointed General Passenger Agent. Mr. A. H. Hawgood has resigned his position as Superintendent of Steamships at Saginaw.

Georgia & Alabama.—The headquarters of Chief Engineer C. P. Hammond, at Meldrim, Ga., has been transferred to Savannah.

Georgia.—Mr. Charles H. Phinizy, formerly President of this road, died at Augusta, Ga., April 28, at the age of 63 years.

Great Northern.—Mr. Louis W. Hill has been appointed Assistant to the President, with office at St. Paul, Minn.

Green Bay, Winona & St. Paul.—Mr. Timothy Case, formerly General Superintendent of this road, died suddenly in Chicago May 9, at the age of 75.

Intercolonial.—Mr. G. R. Joughins has been appointed mechanical Superintendent, vice Mr. F. R. F. Brown, resigned.

Lake Erie & Detroit River.— Mr. Owen McKay has been appointed Engineer, succeeding the late Chief Engineer Joseph DeGurse, whose death occurred on March 22.

Lake Shore & Michigan Southern.—Mr. Addison Hills, Assistant to the President, died at his residence in Cleveland, Ohio, May 7, of pneumonia, at the age of 91 years.

Maricopa, Phoenix & Salt River Valley.—Mr. B. F. Porter has been appointed General Superintendent, with headquarters at Phoenix, Ariz. He was formerly Acting Superintendent.

Minneapolis, St. Paul & Sault Ste. Marie.—Capt. Watson W. Rich, formerly Chief Inspector of this road, has been appointed Consulting Engineer. Mr. John F. Shaughnessey has been appointed Purchasing Agent, with headquarters at Minneapolis, Minn., in place of Mr. T. A. Switz, resigned.

Mobile & Ohio.—Mr. J. J. Thomas, Jr., has been appointed Master Mechanic of the Montgomery Division, with office at Tuscaloosa, Ala.

New York Central & Hudson River Railroad.—Mr. H. J. Hayden, Second Vice-President, will hereafter represent the N. Y. C. & H. R. R. and its allied lines on the Board of Managers of the Joint Traffic Association. Mr. H. Walter Webb having resigned, owing to ill health, the office of Third Vice-President is abolished. The office of General Manager is discontinued, Mr. J. M. Toucey having resigned. Mr. Nathan Guilford, General Freight Traffic Manager, will have general supervision of all freight traffic, and Mr. George H. Daniels, General Passenger Agent, of all passenger traffic, reporting direct to the President. The General Superintendent, Chief Engineer, Superintendent of Motive Power and Rolling Stock, and the Purchasing Agent will hereafter report to the President direct.

New York, Chicago & St. Louis.—Mr. William H. Canniff has been elected as President of this road, succeeding Mr. Samuel R. Callaway, who has been made President of the New York Central & Hudson River.

New York, New Haven & Hartford.—Mr. W. E. Chamberlain has been appointed General Superintendent of the Old Colony system, succeeding Mr. E. G. Allen, resigned.

Norfolk & Western.—Mr. Jos. Longstreth has resigned as Road Foreman of Engines to accept a position as Master Mechanic of the Schoen Pressed Steel Co., of Pittsburg, Pa.

Ohio River & Charleston.—Mr. Simon Davis has been elected Vice-President, succeeding Mr. Job H. Jackson.

Panama.—Mr. F. S. Higbid has been appointed Assistant Engineer. He was formerly Roadmaster of the New York division of the Erie.

Panama.—Mr. Percy Webb has been appointed Master Mechanic, with office at Colon, Colombia, vice Mr. D. G. Mott, deceased.

Pennsylvania.—Mr. Daniel S. Newhall, heretofore Assistant Secretary, has been appointed Purchasing Agent.

Pittsburgh, Chartiers & Youghiogheny.—Mr. Jos. Wood has been elected President, vice Mr. E. B. Taylor, elected Vice-President.

Richmond & Petersburg.—Mr. Frederick R. Scott, President of this road, died at his home in Richmond, Va., Sunday, May 15.

Roaring Creek & Charleston and Roaring Creek & Belington.—Mr. Henry C. Terry, formerly Vice-President and General Solicitor, has been elected President, succeeding Mr. S. P. Diller. Mr. E. P. Rease is General Superintendent, with office at Belington, W. Va. Mr. Thomas Fisher has been appointed General Manager, with office in Philadelphia, succeeding Mr. O. W. Womelsdorf.

Sierra Ry of California.—Mr. H. J. Crocker has been elected Vice-President, with office at San Francisco, Cal.; Mr. S. D. Freshman continuing in his office of Treasurer as heretofore.

Sioux City & Northern.—At the annual meeting held in Sioux City, Ia., May 11, Mr. Samuel J. Beals was elected President. Mr. Craig L. Wright was elected Vice-President, and Mr. Howard S. Baker, Secretary and Treasurer, all of Sioux City, Ia.

Tecumseh.—Mr. J. W. Lewis is General Manager of this road.

Wabash.—The jurisdiction of Assistant Master Mechanic Hollingshead, of the Wabash, with headquarters at Ashley, has been extended over the car department.

Washington & Columbia River.—Mr. C. S. Mellen has been elected President.

White River, Lonoke & Western.—Mr. J. N. Wooley, of Wooley, Ark., was recently elected General Manager, and Mr. Dan Daniel, heretofore Secretary, was elected Vice-President. The general office is at Lonoke, Ark.

Wiscasset & Quebec.—Mr. G. P. Farley has been appointed General Manager, with office at Wiscasset, Me., vice Mr. W. F. P. Fogg.